



Assessing the carbon dioxide emissions and cost-effective carbon savings potential for organisations not covered by EU ETS, CCAs or CRC (CESA 0903)

Final report to DECC

Restricted Commercial

ED49803

October 2010

Title	Assessing the carbon dioxide emissions and cost-effective carbon savings potential for organisations not covered by EU ETS, CCAs or CRC
Customer	DECC
Customer reference	CESA 0903
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File reference	
Reference number	ED49803- Issue 1

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Executive summary

Existing energy efficiency policies, such as the EU Emissions Trading System (EU ETS), the Carbon Reduction Commitment Energy Efficiency Scheme (CRC) and Climate Change Agreements (CCAs) help to mitigate CO₂ emissions from industrial activities, and non domestic buildings; while the Carbon Emissions Reduction Target (CERT) drives the take-up of abatement measures in the domestic sector. However, a high number of smaller, less energy-intensive organisations fall outside the remit of these binding policies, yet, collectively, make significant contributions to the UK's total emissions of greenhouse gases.

This study has been commissioned to develop an improved understanding of the scope and scale of emissions in this 'unconstrained' sector, and the cost of abating these emissions by 2020. The primary focus of the study is on emissions associated with energy use in buildings and in industrial processes. However, a preliminary assessment has also been carried out on the transport-related emissions from vehicles owned by organisations in the unconstrained sector.

Energy and CO₂ emissions assessment

Organisations in the unconstrained sector have an estimated annual energy use of 182 TWh. This applies to energy use from stationary sources, such as space heating and lighting in buildings, or manufacturing processes within industry. When expressed in terms of the associated CO₂ emissions, the sector is responsible for 49 Mt CO₂/year, with 69% of these emissions arising from the service sector and the remaining 31% from industry. In total, this is equivalent to 24% of the greenhouse gas emissions from the UK industry and service sectors.

An estimate has also been made of the emissions associated with mobile sources (i.e. transport related). While not directly comparable with the estimate for stationary sources, due to some differences in scope, we estimate emissions of around 37 Mt CO₂ from business-owned vehicles. This estimate does not include indirect emissions, for example, business travel by employees in privately owned vehicles.

It is also important from a carbon budget perspective to understand the proportion of emissions that are associated with sectors outside the scope of the EU ETS. For the stationary emission sources 56% (i.e. 27 Mt CO₂) fall within the non-traded sector. Almost all of the emissions arising from transport can be considered non-traded.

These estimates are not without uncertainties. For the industrial and services sectors a key uncertainty relates to the coverage of existing policy instruments. While emissions associated with the existing policies EU ETS and CCAs are relatively well documented, the coverage of CRC is much more uncertain. For the transport sector, the main uncertainty relates to the allocation of total business related emissions to the unconstrained sector.

Abatement potential

Cost-effective savings of 7.8 Mt CO₂/year are available from organisations within the unconstrained sector. The majority of the savings are associated within abatement measures within public and commercial sector buildings, where we estimate a technical potential of around 7.2 Mt CO₂/year. This includes measures such as more efficient boilers, heating and lighting controls and behavioural measures. However, a good proportion of this technical abatement potential is expected to be taken up in response to existing and planned policies. After taking these policies into account, the estimated cost-effective abatement potential remaining in 2020 is reduced to 2.0 Mt CO₂/year.

For those industrial activities that form part of the unconstrained sector we estimate a cost-effective abatement potential of around 0.6 Mt CO₂ in 2020, equivalent to around 5% of industrial unconstrained sector emissions. Since most of the policies targeting energy efficiency measures in industry relate to 'constrained' organisations, existing policies are not expected to deliver the bulk of this abatement potential.

Taken together, the cost-effective abatement potential available in 2020 from energy efficiency measures in building and industrial processes is estimated to be 2.6 Mt CO₂/year. This represents the remaining technical potential once the influence of existing and planned policies has been accounted for. The abatement potential is larger in the non traded sector (2.2 Mt CO₂) than in the traded sector (0.4 Mt CO₂). This can be explained in part by the strong influence of products policies on emissions from electricity consumption.

Further to the energy efficiency measures, alternative energy supply technologies, including conventional gas-CHP and renewable heat and electricity have the potential to deliver significant reductions in emissions from the sector. Much of the current potential is not cost-effective without further Government support. When the impact of recently announced policies, such as the Renewable Heat Incentive (RHI) and the Feed-in Tariffs (FITs), are taken into account, the savings from renewable energy in the unconstrained sector might amount to over 2.4 Mt CO₂/year by 2020. Further savings will also be delivered by conventional gas-CHP.

There are important and complex interactions between alternative energy supply technologies and energy efficiency measures. The current analysis assumes only limited overlap between the estimated savings from the two types of abatement measure. However, as the take-up of energy efficiency and renewable energy measures increases these interactions become increasingly important, as does the risk of double counting savings. This is an area where further work should be targeted.

In the transport sector, technical abatement measures have the potential to reduce emissions by around 4.5 Mt CO₂/year or 12% of the sectors total direct carbon footprint from transport. However, from a social perspective none of this potential is cost-effective at current energy prices. Nevertheless, existing policies are expected to drive the take-up of a proportion of these abatement measures. The most important policies relate to alternative fuels e.g. biofuels, or improvements in the efficiency of vehicles either through regulations (for passenger cars and vans) or voluntary agreements. Taking into account the expected impact of these policies reduces the technical abatement potential in 2020 to 2.8 Mt CO₂. This estimate does not include potential savings from demand side measures.

Barriers and drivers

There are a number of important barriers that may limit the take-up of abatement measures, even if the economic case is strong. To understand these barriers in more detail, some new market research has been carried out. This has provided an improved understanding of the available measures to overcome barriers to the uptake of energy and fuel efficiency measures within 'unconstrained' businesses.

400 interviews were conducted with businesses in England that lie within the 'unconstrained' sector. All non-domestic sites were prompted as to the level of action that they had taken in the areas of Lighting, Heating and Insulation. All sites that operated vehicles were also prompted as to the level of action that they had taken to improve their fuel efficiency.

Across all business sectors and sizes, cost savings were found to be the principal motivation for action and a factor in the decisions of most sites to take action to implement energy saving measures. Reducing environmental impact was also found to be important for some businesses, while for insulation activity increased comfort was a powerful motivator for action. Reducing environmental impact was found to be a much more important motivator for action at industrial sites than at commercial sites.

Larger organisations and those in owned premises were found to be more likely to have taken action and to feel that there is more they could do to reduce their impacts. Smaller sites and those in rented premises generally do not feel they have as much room for manoeuvre, in part due to lack of resources but also due to tenant limitations (i.e. they don't own the buildings they operate from).

Lack of funding and lack of knowledge as to what can be done (coupled with a perception that everything sensible has been done already) have arisen as theoretical barriers in many previous research reports. This research has confirmed these as the two principal barriers for sites. Overcoming these barriers may be achieved by a combination of funding mechanisms and tailored site reviews.

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1 Introduction

Chapter summary

- The unconstrained sector refers to organisations whose energy use and CO₂ emissions are not covered by existing binding policy instruments (i.e. EU ETS, CCAs, CRC). This includes stationary emissions (e.g. from energy use in buildings) but also emissions from mobile sources (e.g. road transport).
- There is a wide variation in the previous estimates that have been made of the emissions coverage of the unconstrained sector. Similar variability exists in the estimates of the abatement potential. Developing policy with this variability in the evidence base presents a risk for policy makers.
- This study has been commissioned to address this weakness in the evidence base. It has estimated the energy use and CO₂ emissions from organisations within the unconstrained sector, and also the estimated cost of reducing these emissions by 2020. Research has also been carried out into the importance of different barriers faced by organisations within the unconstrained sector.

1.1 Background

The Climate Change Act 2008 introduced the world's first long-term legally binding framework to tackle climate change. The Act aims to encourage the transition to a low-carbon economy in the UK through unilateral legally binding emissions reduction targets. This means a reduction of at least 34 percent in greenhouse gas emissions by 2020 and at least 80 percent by 2050. The cost-effective delivery of these targets will require contributions from all sectors of the economy.

Energy use within industries, businesses, public sector organisations and institutions are already covered by existing energy efficiency/ carbon abatement policies such as the EU Emissions Trading System (EU ETS), the Carbon Reduction Commitment Energy Efficiency Scheme (CRC) and Climate Change Agreements (CCAs); while the Carbon Emissions Reduction Target (CERT) drives the take-up of abatement measures in the domestic sector. However, a high number of smaller, less energy-intensive organisations, businesses and institutions fall outside the remit of these binding policies, yet, collectively make significant contributions to the UK's total emissions of greenhouse gases.

Furthermore, emissions from transport activities are also largely unconstrained, at least in terms of absolute limits on emissions from end-users¹.

To assess the most effective way of stimulating the take-up of CO₂ abatement measures by organisations not covered by existing binding policy instruments, it is important for DECC to have a better understanding of the composition of this 'unconstrained sector', the emissions of CO₂ from the sector, and the scope for targeting reductions in these emissions.

Building upon the previous work in this area, and drawing on a range of new data, this report provides an estimate of the energy use and CO₂ emissions from organisations within the unconstrained sector, and the estimated cost of reducing these emissions by 2020. The research has been led by AEA, with specialist input from the market research company Databuild.

¹ The main emission controls associated with transport relate to emission standards imposed on vehicle manufacturers, and fuel requirements imposed on fuel suppliers.

1.2 Aims and objectives

The primary aim of the study is to develop an improved understanding of the scope and scale of emissions within the unconstrained sector, and the cost of abating these emissions. While the study has not explicitly considered the policy instruments that might be employed to drive the take-up of abatement measures, it has examined the potential influence of alternative carbon prices on the take-up of abatement measures.

The specific objectives of the study are as follows:

- Assess the carbon dioxide emissions from business and public sector organisations that fall outside the scope of existing quantified policy tools (CRC, CCAs, EU ETS and CERT).
- Estimate the potential scope for reducing these emissions at different carbon prices.

A secondary aim of the study is to improve the understanding of the drivers and barriers to the take-up of energy efficiency measures within the unconstrained sector. Previous research has shown that even if the economic case is strong, other barriers exist which mean the take-up of energy efficiency measures is lower than would be predicted from economic models. To understand these barriers in more detail some specific market research has been commissioned as part of this project. Led by Databuild, the research has sought to understand and rank the importance of different barriers faced by organisations within the unconstrained sector.

1.3 Scope and coverage

The primary focus of the study is on emissions associated with energy use within buildings, and in industrial processes. This includes energy used for heating, cooling and lighting buildings, as well as energy used by electronic equipment such as computers. It also includes energy used within industrial activities, such as heat required in manufacturing processes. While a proportion of these emissions will be covered by existing binding policies, such as CRC and CCAs, the remainder are largely unconstrained by policy. It is these emissions that are the focus of the current study.

The above definition of the unconstrained sector is largely restricted to emissions from stationary sources, such as buildings. However, the organisations that make up the unconstrained sector will also be responsible for direct emissions of CO₂ from mobile sources (e.g. transportation). These transport related emissions are potentially as significant as emissions from stationary sources, and are effectively unconstrained from the perspective of the end user. On this basis the scope of the current study has been expanded to include a preliminary assessment of the emissions associated with energy use from transportation.

The analysis is restricted to emissions from energy use, and does not include non-CO₂ greenhouse gases from industrial processes, or emissions associated with other resource use such as waste production or water consumption. These issues could be examined as part of further research so as to provide a more holistic assessment of the impacts of the sector on greenhouse gas emissions.

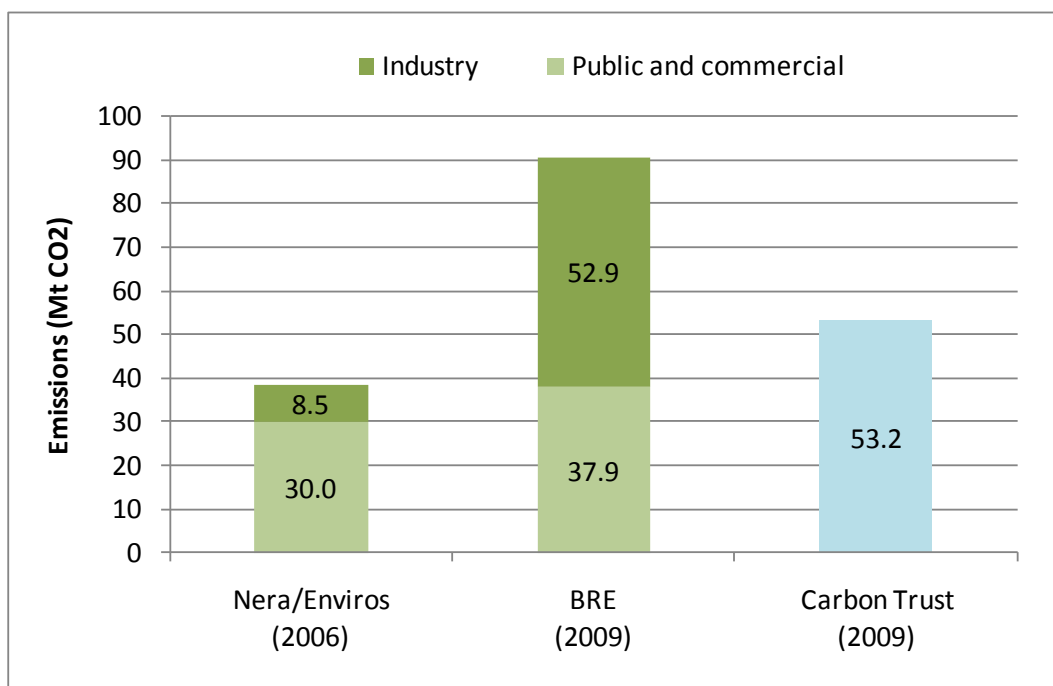
1.4 Review of previous estimates

A number of previous studies have attempted to estimate the scope and scale of emissions within the unconstrained sector, with some studies also estimating the abatement potential from the sector. The results from these studies are summarised in the figures below, with further analysis provided in Annex 1. All of the studies relate to energy use from non domestic buildings and industrial activities. No estimates were identified of the abatement potential from transport related emissions that were specific to organisations within the unconstrained sector.

The results from the previous studies are not directly comparable due to differences in scope and methodological assumptions (e.g. discount rates, emission factors, energy prices). However, the estimates do exhibit a large variation in both the absolute emissions (see Figure 1-1) and also the proportion of the emissions that can be abated by cost-effective measures (see Figure 1-2). The updated analysis in this current study aims to derive a more accurate estimate.

On the basis of the estimates made in these previous studies, emissions from the unconstrained organisation in the public and commercial sector may fall in the range 30 – 38 Mt CO₂/year. For the industry sector the estimated coverage is much more uncertain, with a range of 9 – 53 Mt CO₂. This variation can largely be explained by the differences in the scope of the previous studies, and the assumptions that have been made on the coverage of existing policy instruments.

Figure 1-1: Previous estimates of the emissions associated within the unconstrained sector



Notes: Carbon Trust (2009) estimate is for all non-domestic buildings, so includes energy use within public, commercial and industrial buildings, but excludes energy use from industrial processes. BRE (2009) results are based on further analysis of BRE data by AEA for use in this project.

Energy efficiency measures and certain alternative energy technologies have the potential to deliver reductions in energy and/or carbon emissions while also delivering financial savings. In simple terms, this means that the measures deliver energy bill savings that are greater than the upfront costs of installing the measures, the on-going maintenance costs, and any other costs. This defines, for a given set of economic conditions (e.g. discount rate assumptions, energy prices etc) the cost-effective potential. To meet its long term mitigation targets the UK will need to take up a wide range of measures and not all will be cost-effective as defined here. However, it is clear that where measures can be implemented that deliver emissions savings while also providing financial savings to the end user, they should be given priority. This is why previous studies of the unconstrained sector have focussed on the assessment of the cost-effective abatement potential.

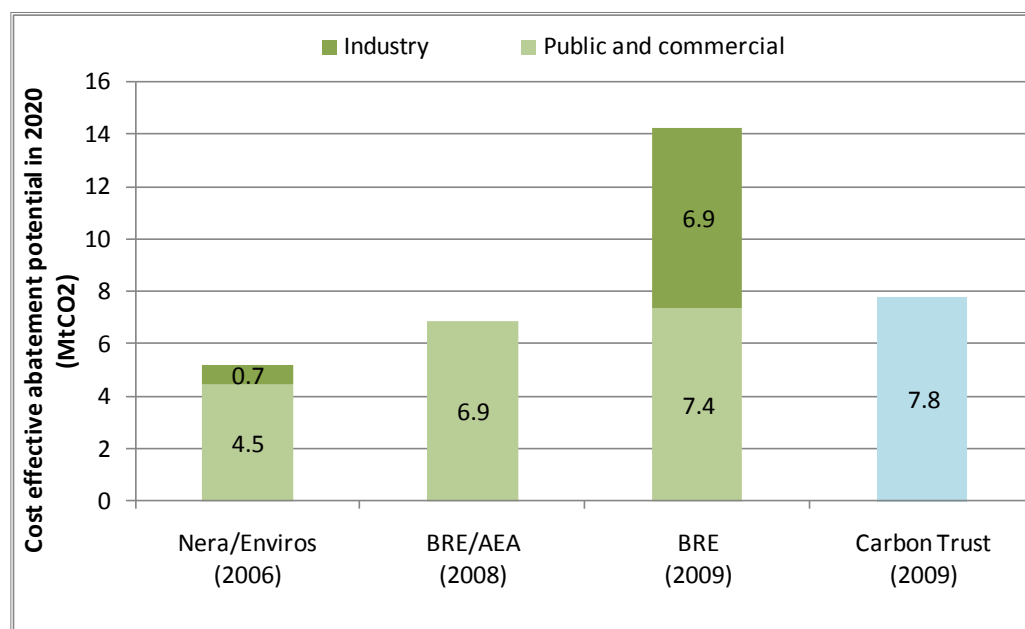
The figure below makes a comparison of previous estimates of the cost-effective abatement potential² from the unconstrained sector. The estimates once again show less variation for public and commercial buildings, which reflects the lower variability in the estimated emissions coverage of these sectors. Interestingly, all of the more recent estimates suggest a larger abatement potential than the initial work that was carried out by NERA/Enviros.

It is also important to recognise that the estimates shown in the figure below refer to the absolute level of technical potential. They do not necessarily reflect a very realistic set of assumptions about the uptake of measures, for example by accounting for the potential barriers to take up, or the impact of existing policies. Where these factors have been explicitly accounted for the remaining abatement potential from the sector in 2020 can reduce by c. 40-60% (based on NERA/Enviros, 2006), or c. 50%

² Different assumption with respect to the discount rates, energy prices and the cost factors that are included in the cost-effectiveness calculation mean that estimates from different studies may not be directly comparable.

(based upon the Element Energy, 2009). Therefore, understanding these factors is important for estimating the true policy gap.

Figure 1-2: Previous estimates of the cost-effective abatement potential within the unconstrained sector



Notes: Carbon Trust estimate is for all non-domestic buildings, so includes energy use within public, commercial and industrial buildings, but excludes energy use from industrial processes. BRE (2009) results are based on further analysis of BRE data by AEA for use in this project. Results for Element Energy (2009) are not shown separately in the figure as they are broadly consistent with those reported for BRE/AEA (2008) as they are based on the same dataset.

Overall, the variation in the estimated emissions and abatement potential from the sector can be explained partly by differences in the scope of the studies (for example, some included industrial emissions and other did not). However, there are other important factors that influence the estimated abatement potential. In particular, the review of existing studies identified three areas that have an important influence on the extent of the abatement potential in 2020. These are:

1. The proportion of total UK energy use and carbon emissions that is allocated to the unconstrained sector. This in turn relates to the assumed coverage of existing policy instruments, in particular CRC.
2. The cost-effective abatement potential from measures applied to the sector. This also takes into account methodological differences in assessing the cost-effective potential such as the base year, the fuel mix assumptions, the treatment of hidden costs³, the treatment of measures interaction, the influence of energy prices and discount rates.
3. The realistic uptake of the abatement measures in the future, in response to existing policies and other drivers/barriers.

Taking into account the findings from this review, the analysis in this report has specifically focussed on each of the three areas described above.

³ Hidden and missing costs refer to hidden time and financial costs when implementing a measure. For example, additional time required for the project identification/appraisal or the additional engineering costs to reinstall heating/pipes after putting an alternative heating system in place.

1.5 Structure of the report

This report is structured in 4 separate sections, in addition to this introduction. The structure is as follows:

- Section 2: Assessment of the energy and CO₂ emissions from the unconstrained sector.
- Section 3: Assessment of the abatement potential from the sector.
- Section 4: Assessment of the impacts of existing policies on the abatement potential.
- Section 5: Assessment of the barrier and drivers to the take-up of abatement measures.

While the analysis of the emissions and abatement potential from stationary and mobile sources has been carried out separately, using different methodologies, the results have been integrated within the main report. Further details on the methodologies and results for each of the individual sectors are provided in separate appendices to the report.

2 Energy and CO₂ emissions assessment

Chapter summary

- Organisations in the unconstrained sector have an estimated annual energy use of 182 TWh. This applies to energy use from stationary sources, such as space heating and lighting in buildings, or manufacturing processes within industry.
- When expressed in terms of the associated CO₂ emissions, we estimate that the sector is responsible for 49 Mt CO₂/year, with 69% of these emissions arising from the service sector and the remaining 31% from industry. In total, this is equivalent to 24% of the greenhouse gas emissions from the UK industry and service sectors.
- An estimate has also been made of the emissions associated with mobiles sources (i.e. transport related). While not directly comparable with the estimate for stationary sources, due to some differences in scope, we estimate emissions of around 37 Mt CO₂ from vehicles owned by small and medium-sized enterprises (SMEs).
- It is also important from a carbon budget perspective to understand the proportion of emissions that are associated with sectors outside the scope of the EU ETS. For the stationary emission sources 56% (i.e. 27 Mt CO₂) fall within the non-traded sector. Almost all of the emissions arising from transport can be considered non-traded.
- These estimates are not without uncertainties. For the industrial and services sectors a key uncertainty relates to the coverage of existing policy instruments. While emissions associated with the existing policies EU ETS and CCAs are relatively well documented, the coverage of CRC is much more uncertain.
- For the transport sector, the main uncertainty relates to the allocation of total business related emissions to the unconstrained sector.

2.1 Introduction

The starting point for the analysis is an understanding of the energy and CO₂ emissions that can be attributed to those organisations that make up the unconstrained sector. This includes 'stationary' energy use in non domestic buildings and in industrial activities. It also includes 'mobile' energy use associated with transport activities.

2.2 Definition of the unconstrained sector

For the purposes of the current study the unconstrained sector has been described in terms of those organisations whose energy use is not covered by current binding UK energy efficiency or carbon abatement policy. More specifically the sector has been defined in terms of the energy use in non domestic buildings and industrial activities that is not covered by the EU ETS, CCAs or CRC. Energy use from domestic buildings has been excluded; these emissions are assumed to be covered by CERT.

In emissions terms, the unconstrained sector can be estimated 'top-down' by calculating the residual emissions after removing the EU ETS, CCA and CRC emissions from total UK public, commercial and industry sector emissions. Of the current policies, the coverage of the CRC has the greatest uncertainty as the scheme has yet to begin. Therefore, achieving a good understanding of the scope of the emissions covered by CRC is very important for determining a more accurate assessment of those emissions that are 'unconstrained'.

The coverage of each of the above instruments is summarised in the table below.

INSTRUMENT	SUMMARY OF SECTORS/ ORGANISATIONS REGULATED
EU ETS	Installation based. Predominantly energy intensive heavy emitting installations defined under Directive 2003/87/EC (Amended). Including: Power Sector and energy-intensive industries (e.g. Refining of mineral oil, Metal ore processing)
CRC	Organisation based. Organisations that satisfy the qualifying criteria will be included: - At least one half-hourly meter (HHM) settled on the half hourly market; and, - Electricity consumption in 2008 through all HHMs was $\geq 6,000$ MWh/year. Including: Large, predominantly non-energy-intensive private and public sector organisations such as all central Government departments, NHS, large retailers, banks, local authorities and state schools.
CCA	Site based. Energy use from processes and industries satisfying qualifying criteria will be included. Focus of CCAs is energy intensive organisations subject to international competition. Energy Intensive Industries as defined by: - The Pollution Prevention and Control regulations 2000, or; - Energy Products Directive 2004.

All transport related emissions, with the exception of certain vehicles used on-site, fall outside of the scope of the EU ETS, CCA and CRC. For the purposes of the current study, and to ensure consistency with the assessment of emissions from buildings and industrial activities, the scope of the analysis of the transport related emissions has been restricted to just those organisation that fall within the unconstrained sector. In other words, an estimate has been made of the transport related emissions that are associated with those organisations whose site energy use is 'unconstrained' according to the definition provided above. Since this definition of the unconstrained sector does not map across to the transport sector perfectly, it has been assumed that a large proportion of organisations that fall within the unconstrained sector are likely to be SMEs i.e. companies employing fewer than 250 people. On this basis, the unconstrained sector, for the purpose of the transport analysis, refers to businesses in the SME sector.

2.3 Estimation methodology

2.3.1 Stationary sources

For stationary sources, our analysis starts with the data on total UK energy consumption in the industry and service sectors that are reported in Digest of UK Energy Statistics (DUKES). From this total, we then remove energy consumption covered by EU ETS, energy covered by CCAs and finally the energy that we estimate will be covered by the CRC. The residual from this top-down approach can be considered to represent the energy consumption in the unconstrained sector. Further details of the methodology and calculations performed can be found in Appendix 2.

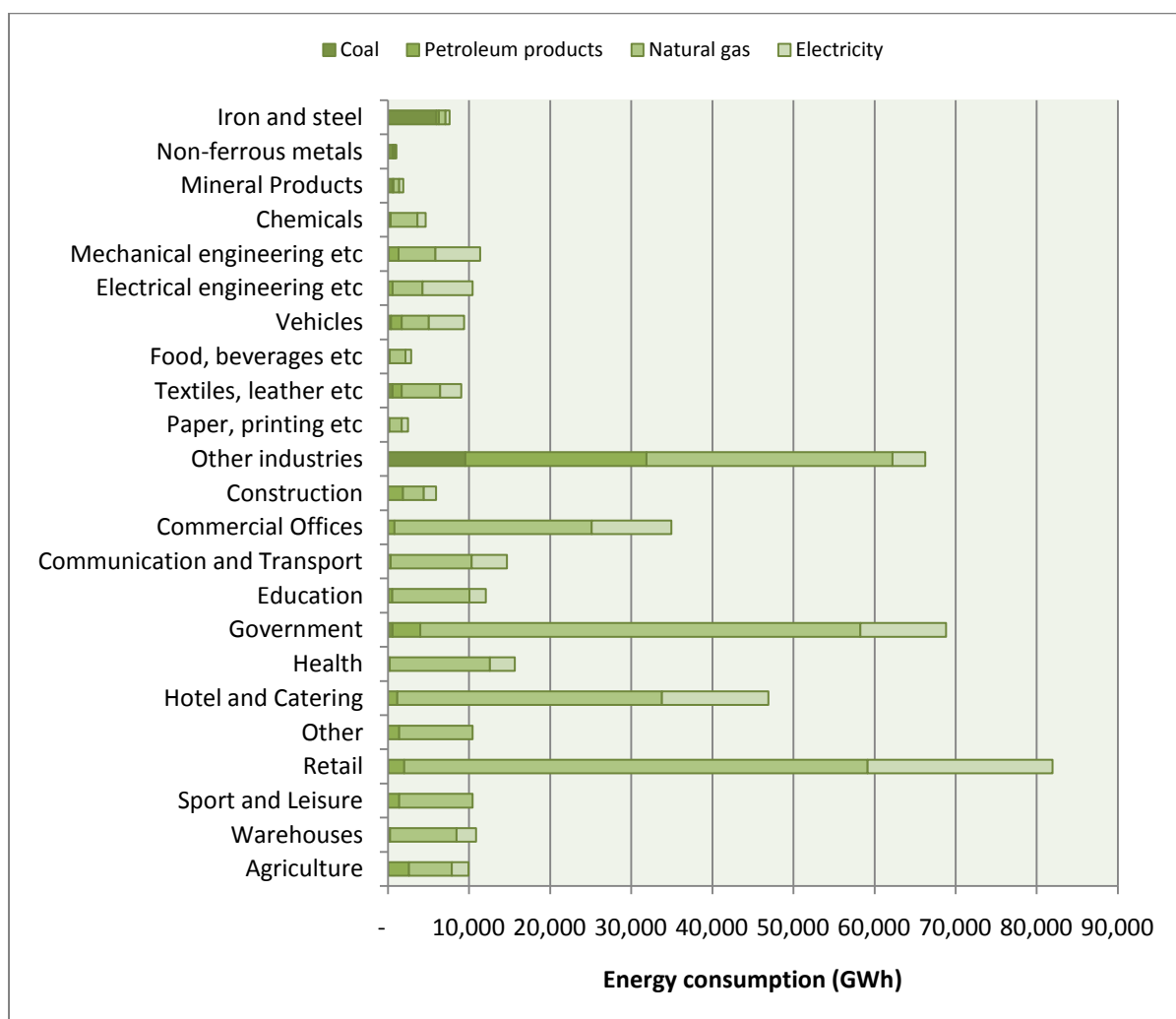
The total UK energy consumption in the industry and service sectors is shown in Table 2-1. Around 25% more energy is consumed in the industry sector than in the service sector. The largest consuming sectors in industry are iron & steel and mineral products and other industries, while the retail sector consumes the most energy in the service sector.

Table 2-1: 2008 UK energy consumption in the industry and service sectors split by fuel and sub-sector (in GWh)

Sector	Coal	Petroleum products	Natural gas	Electricity	Total
Industry	98,141	50,266	197,822	82,810	429,039
Iron and steel	59,701	3,180	8,210	4,890	75,981
Non-ferrous metals	9,545	543	3,303	3,087	16,478
Mineral products	8,830	2,016	11,091	7,756	29,693
Chemicals	3,311	2,370	51,331	15,738	72,750
Mechanical engineering, etc	121	1,210	8,713	7,841	17,886
Electrical engineering, etc	46	542	3,897	6,979	11,464
Vehicles	395	1,348	8,635	5,595	15,972
Food, beverages, etc	370	3,316	30,239	10,712	44,638
Textiles, leather, etc	622	1,211	6,101	3,184	11,117
Paper, printing, etc	1,535	767	20,401	9,770	32,472
Other industries	13,666	31,914	43,319	5,753	94,652
Construction	-	1,848	2,583	1,505	5,937
Service	1,145	16,736	240,516	72,062	330,460
Commercial offices	14	859	24,477	9,830	35,180
Communication and transport	6	382	10,879	4,369	15,635
Education	135	743	10,683	2,043	13,604
Government	696	3,838	55,197	10,554	70,285
Health	202	1,114	16,025	3,064	20,405
Hotel and catering	18	1,145	32,636	13,107	46,906
Other	-	1,410	9,033	-	10,443
Retail	32	2,004	57,113	22,937	82,086
Sport and leisure	-	1,410	9,033	-	10,443
Warehouses	5	286	8,159	3,277	11,727
Agriculture	39	3,545	7,282	2,881	13,746

Removing the EU ETS and CCA energy consumption from the total leaves a residual that should be accounted for by CRC and the unconstrained sector.

Figure 2-1: Residual energy consumption after removing EU ETS and CCA energy split by fuel type and sector. Representative of 2008

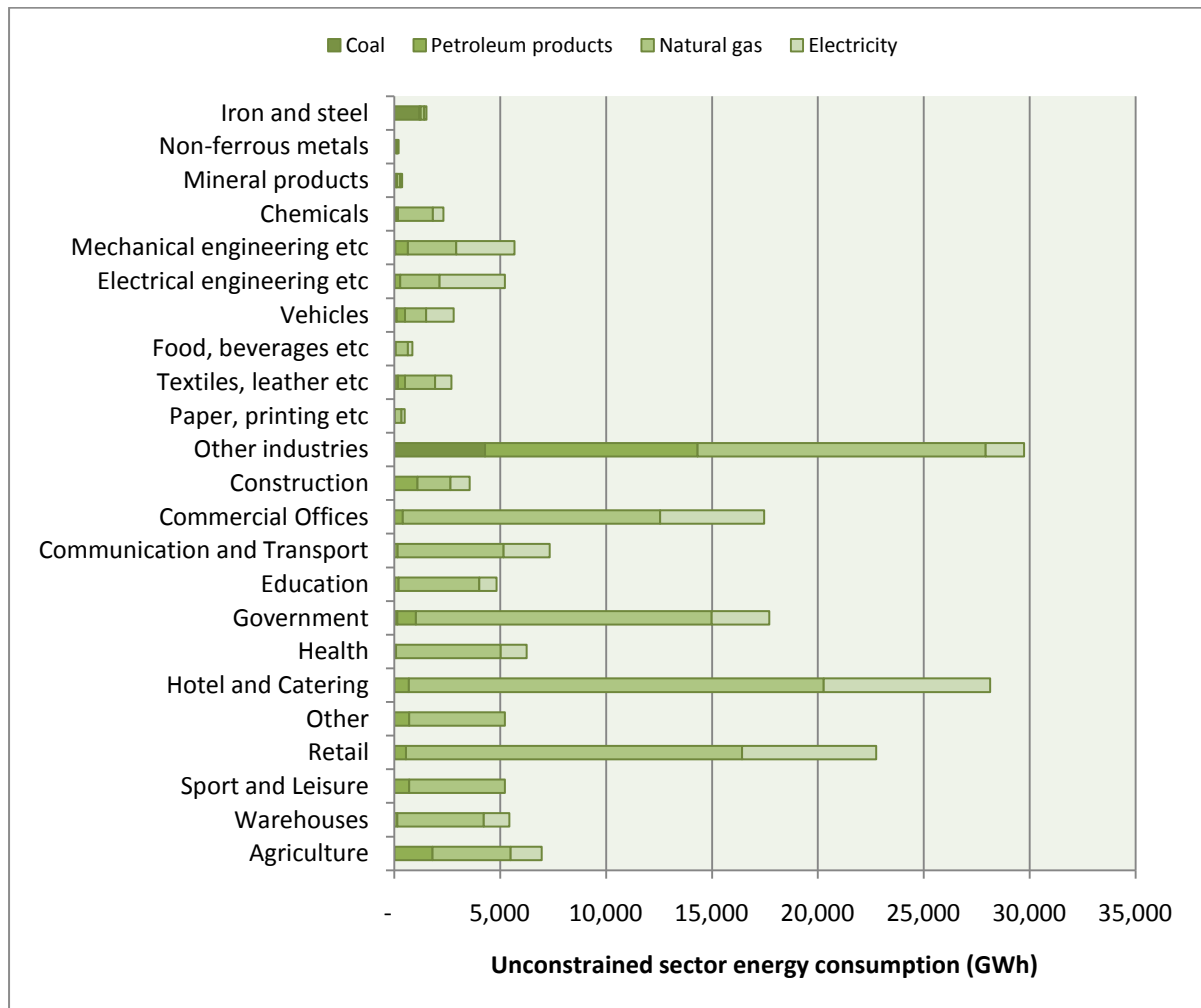


The final step in determining the energy consumption within the unconstrained sector is to remove the estimated energy use that is covered by the CRC. Once CRC energy is removed the total industry energy consumption is reduced to 55 TWh, while total service sector energy consumption falls to 127 TWh. This is displayed diagrammatically in Figure 2-2.

The main contributors to the unconstrained sector are easily visible, these are:

- Other Industries (16%)⁴.
- Hotels and catering (15%).
- Retail (12%).
- Government (10%).
- Commercial offices (10%).

⁴ Other Industries is comprised of activities falling within SIC Codes: 13- Mining of metal ores, 20 – Manufacture of wood and wood products, 25 – Manufacture of rubber and plastic products, 36 – Manufacturing not elsewhere classified, 37 - Recycling, 41 – Collection, purification and distribution of water

Figure 2-2: Unconstrained sector energy consumption. Representative of 2008

Estimating the CO₂ emissions that are associated with the energy consumption shown in
Figure 2-2 reveals emissions arising from the unconstrained sector of 49 Mt CO₂ with 69% of these emissions associated with energy use in the service sector and the remaining 31% associated with industry (Figure 2-3 and Table 2-3).

Table 2-2: Energy consumption and resultant CO₂ emissions for the unconstrained sector

Sector	GWh	kt CO₂
Industry (total)	55,540	15,328
Iron and steel	1,520	454
Non-ferrous metals	211	67
Mineral products	380	119
Chemicals	2,328	621
Mechanical engineering, etc	5,687	2,045
Electrical engineering, etc	5,229	2,071
Vehicles	2,818	1,003
Food, beverages, etc	857	233
Textiles, leather, etc	2,712	802
Paper, printing, etc	494	147
Other industries	29,743	6,771
Construction	3,562	995
Non-domestic buildings (total)	127,374	33,784
Commercial offices	17,473	4,972
Communication and transport	7,351	2,133
Education	4,839	1,187
Government	17,712	4,254
Health	6,255	1,590
Hotel and catering	28,144	7,990
Other	5,222	970
Retail	22,756	6,452
Sport and leisure	5,222	970
Warehouses	5,435	1,433
Agriculture	6,967	1,833

The relative importance of each of these sub-sectors to the overall emissions from the unconstrained sector is shown diagrammatically in the figure below.

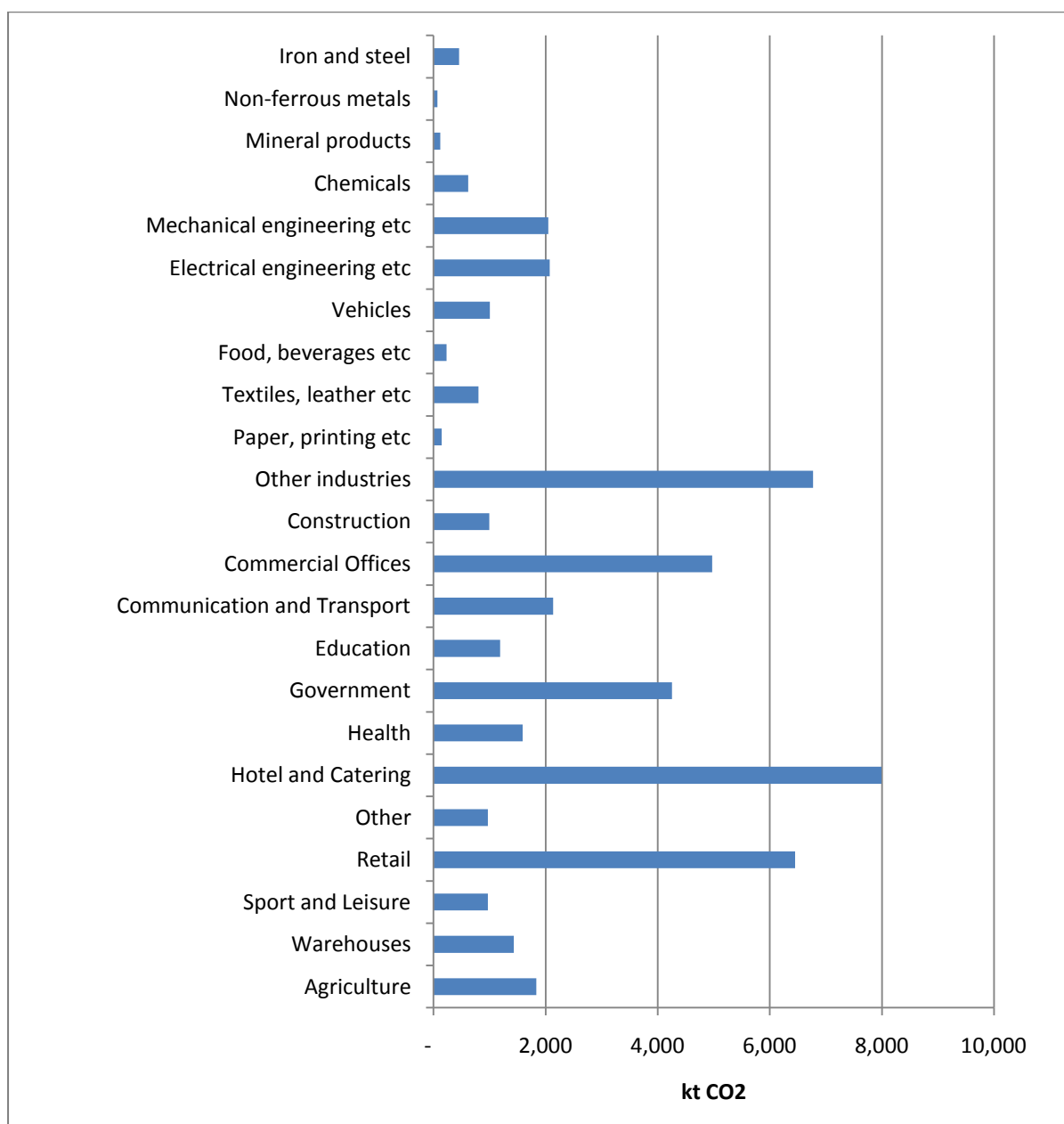
Figure 2-3: CO₂ emissions arising from unconstrained sector energy consumption. Representative of 2008

Table 2-3 summarises the total and unconstrained sector emissions from the calculations carried out here and shows that for industry, an estimated 13% of total sector emissions are unconstrained while for non-domestic buildings 40% of emissions could be unconstrained.

Table 2-3: Summary of total and unconstrained sector emissions in 2008

	Total DUKES 2008 energy related emissions	2008 Unconstrained sector emissions	Unconstrained sector emissions as a proportion of total sectoral emissions
	Mt CO ₂	Mt CO ₂	%
Industry	120.6 ¹	15.3	13
Services	86.8	33.8	40

¹ Excludes 44 Mt CO₂ from energy used in the energy supply sector as this is not consistent with the definition of industry used elsewhere in this report. Also excludes 3.9 Mt CO₂ from energy use in agriculture which is accounted for as part of the Services sector.

Previous estimates of the size of the unconstrained sector suggest that emissions from the unconstrained sector may fall in the range 35 – 90 Mt CO₂ (Figure 1-1). Our calculations of the emission coverage are consistent with this range.

Energy consumption by organisation size

It is useful to understand how the energy consumption in the unconstrained sector is distributed between different sizes of organisation. Since the sector is made up of less energy-intensive organisations it is likely that these organisations will also be smaller in size, with a large proportion likely to be considered SMEs.

The distribution of energy use by size of organisation has been estimated using BIS SME statistics for the UK and regions 2008⁵ and the total energy consumption for the industry and services sectors of the UK economy. Taking the total number of employees within the industry and service sectors and making the assumption that energy consumption per employee remains constant within each sector – so is independent of the size of the organisation - we calculate the mean energy consumption per employee within any organisation.

Organisations within the BIS SME statistics are grouped according to employee number following the definition of the European Commission⁶:

- Micro <10.
- Small <50.
- Medium <250.

SMEs with a headcount of more than 250 are grouped here into a large category.

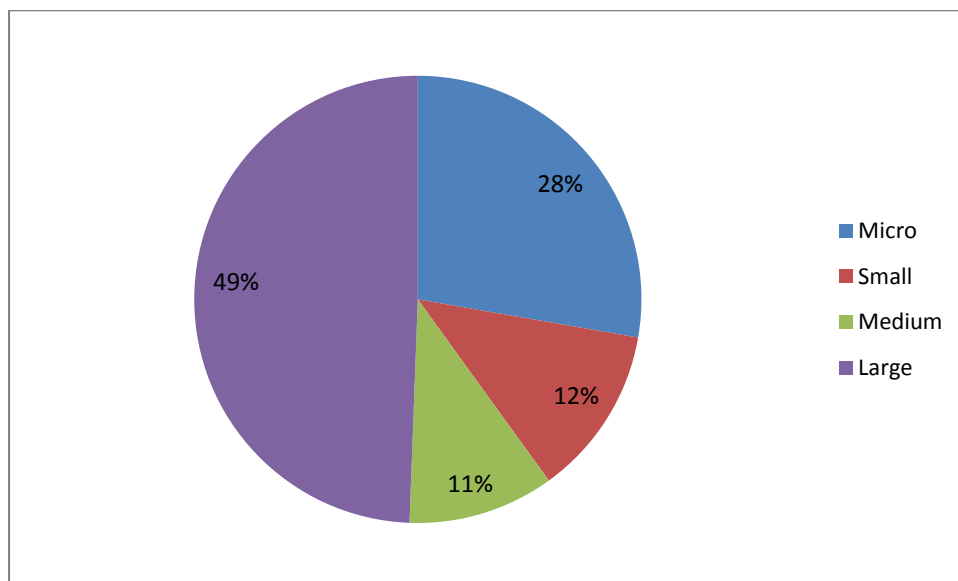
For these groupings, total employment, number of enterprises and mean organisational employment can be calculated. Energy consumption per employee for each sector (or sub-sector) can then be scaled by the organisational characteristics to yield an estimate of the total energy consumption within each of the different size bands. The result is shown in the figure below. No correction has been made for the fact that a proportion of the businesses in the micro category may work from home, so are outside the scope of the 'unconstrained sector' as defined here.

The analysis assumes that the BIS SME statistics provide a reasonable representation of the of the organisational size split within the unconstrained sector. This is not an unreasonable assumption since the estimated electricity consumption of an average organisation in the 'large' SME size band falls below the CRC threshold. This is the case for both the industry and service sectors. This suggests that the large proportion of the organisation represented by the SME statistics will fall below the CRC threshold and therefore are likely to be within the unconstrained sector.

⁵ <http://stats.berr.gov.uk/ed/sme/>

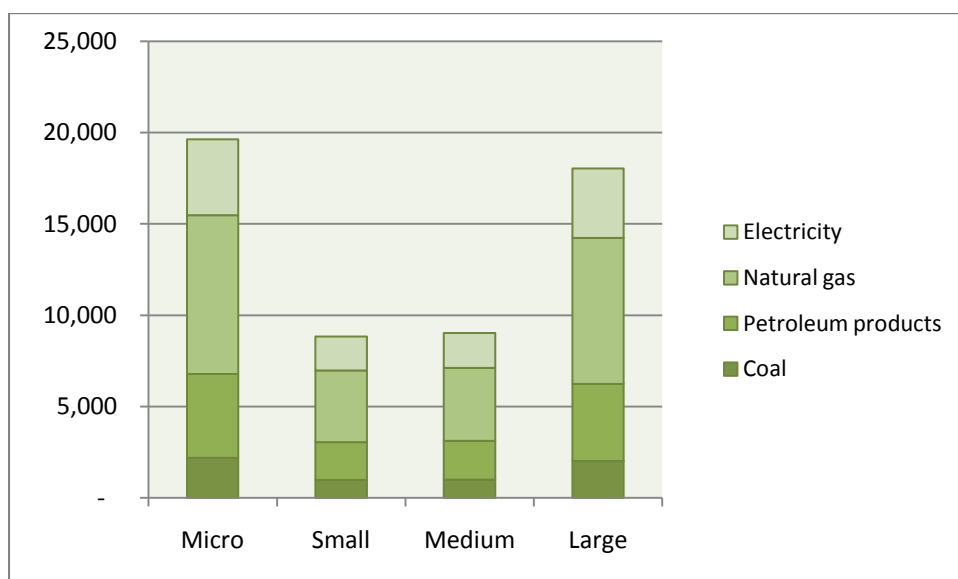
⁶ http://ec.europa.eu/enterprise/policies/sme/facts-figures-analysis/sme-definition/index_en.htm

Figure 2-4: 2008 energy consumption in industry and non-domestic buildings broken down by organisation size (Total = 183 TWh)



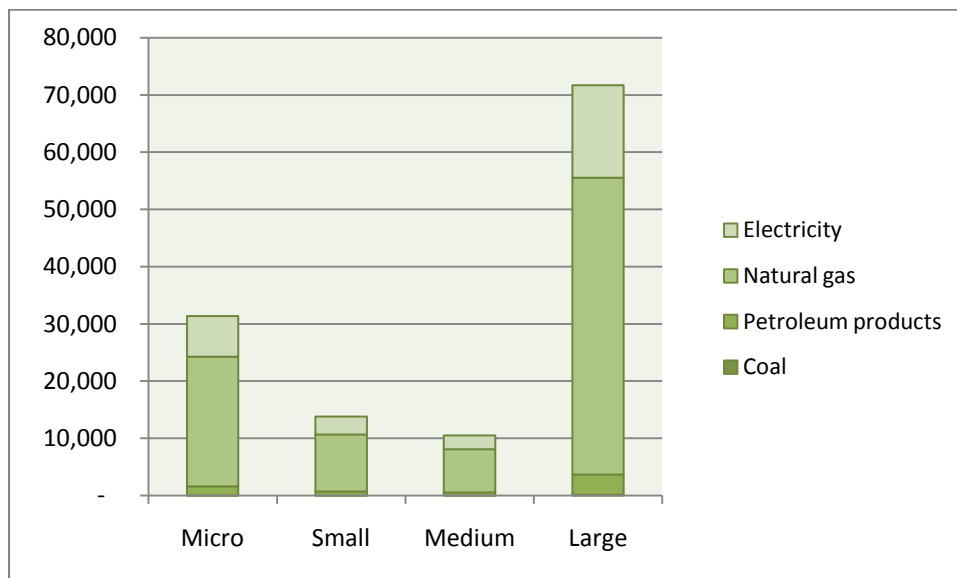
Large and micro-sized organisations are responsible for 77% of the total unconstrained sector energy consumption with SMEs about similar in energy consumption at 11 – 12% (Figure 2-4). In the industry sector, micro sized organisations represent the largest energy consumers, accounting for 35% of total unconstrained industry sector energy consumption, this is followed by large sized enterprises accounting for 32% and then SMEs each representing around 16% (Figure 2-5).

Figure 2-5: 2008 industry sector energy consumption split by organisation size and fuel type



In the unconstrained service sector, 56% of energy is consumed by large-sized SMEs, with micro, small and medium enterprises making up 25%, 11% and 8% respectively (Figure 2-6). The differences between the industry and service sectors result from differences in the distribution of employment by each of the size groupings.

Figure 2-6: 2008 service sector energy consumption split by organisation size and fuel type



Considering SME employment geographically and at the regional level, the statistics suggest that by far the majority (87%) of unconstrained sector energy consumption would occur in England, Scotland would represent 8% with Wales and Northern Ireland comprising 3% and 2% respectively.

It is also useful to understand the proportion of the business that operate from premises that they own and/or pay their own energy bill, since this gives an indication of the proportion of businesses that benefit directly from the installation of cost-effective energy efficiency measures.

In the market research of SMEs described in Chapter 5, 60% of commercial sites interviewed were found to rent their premises from commercial landlords; almost two fifths are owned by the business or the business owners. This is consistent with the 2009 annual survey from the Federation of Small Businesses, where 59% of businesses rent (including lease) and 41% own their premises⁷.

In terms of the payment of energy bills, the market research suggests that in almost all cases, at sites owned by the occupier the business pays the energy bill. However, at rented sites the owner (landlord) pays the bill at just 20% of the sites. On this basis, across the SME sector as a whole, we estimate that the property owner pays the bills for about 52% of the sites, and the tenant pays the bill for 48% of the properties.

Confidence levels

Confidence in the estimated unconstrained sector energy consumption of 183 TWh is high. The number is based on reported energy consumption under EU ETS and CCAs, expert knowledge of the sectors and is consistent with other current estimates of the size of the CRC sector (e.g. SKM Enviro, 2010). However, until the CRC is actually in operation the actual coverage of emissions from this policy will remain more uncertain than for the other policies.

There is also high confidence of the industry and service sector split. However, confidence is lower for the sub-sector splits (at the steel, chemicals, retail level) since there is some uncertainty around the underlying DUKES sub-sector splits, which are not entirely transparent.

Breaking down unconstrained sector energy consumption by organisation size introduces further uncertainty. These results should therefore be treated with further caution than the results for the sector as a whole.

⁷ Federation of small businesses, Annual Survey 2009

2.3.2 Mobile sources

There is currently no established methodology or model for allocating transport related CO₂ emissions to businesses within the SME sector. A top-down methodology has been developed which draws upon the data within the UK Greenhouse Gas Inventory (GHGI), and other sources, to disaggregate the proportion of UK transport emissions that are associated with SMEs. The results from this approach have been compared against those from alternative estimates to cross check and refine the findings.

The GHGI represents the official data on historical emissions of greenhouse gasses within the UK, as reported by the UK Government to the UNFCCC⁸. The GHGI draws upon a wide range of data sources, and is fully consistent with the transport statistics that are prepared by the Department for Transport (DfT). The results from the GHGI disaggregation were compared with published data on vehicle kilometres and travel behaviour by mode of transport, and also data on the estimated transport related emissions from different economic activities. This was used to refine the primary approach, to derive an estimate of the emissions associated with different transport modes and journey types, and then to disaggregate the results into industry sub-sectors.

The estimation of the emissions followed the following sequential steps:

1. Assessment of the emissions by mode.
2. Assessment of the business related emissions.
3. Assessment of the SME component of business-related emissions.
4. Assessment of the emissions by industry sector.

A full description of the methodology is provided in Appendix 3.

In estimating the emissions from businesses it is important to make a distinction between direct and indirect emissions. We have defined **direct** emissions as those arising from vehicles owned by the company, including cars or owner operator vans through to fleets and smaller freight operators. This will also cover company cars, taxi firms and hire car firms. **Indirect** emissions include travel associated with business activities but not in company owned vehicles. Examples of this are travelling by rail to meetings or commuting to work in a privately owned car.

While it is relatively easy to define direct and indirect emissions for a specific organisation, it is less so for the UK as a whole. For example, a SME may own or operate a fleet of vehicles, e.g. some taxis. However, the users of the vehicles could be other SMEs, larger business users, or could be non-business users. Therefore, if the emissions are allocated on a 'direct' basis, then the results will differ (for the given mode⁹) from where an 'indirect' approach has been used to allocate the emissions. Hence, for the illustration of taxis, from the SME taxi owners' perspective the CO₂ emissions are direct business emissions, whereas from the users' perspective the emissions are either indirect business (SME or large business) or private usage.

For this reason emissions have been estimated both on a 'direct' and an 'indirect' basis. These estimates cannot be combined at a UK level as this will effectively double count a certain proportion of the emissions. The estimate of the indirect emissions should be considered illustrative and has been included to highlight that certain emissions associated with SMEs will be in vehicles that they do not own, so cannot be influenced in the same way as company owned vehicles. However, these indirect emissions are still important.

Furthermore, the analysis of indirect emissions is focussed on passenger transport, excluding emissions associated with freight transport e.g. the transportation of paper to an office. The analysis also excludes emissions arising outside of the UK e.g. travel to international business meetings. Including these emissions would add a great deal more complexity, and its inclusion would require further steps to ensure the emissions involved were not double counted.

⁸ United Nations Framework Convention on Climate Change

⁹ This is more applicable to certain modes than others. For example, vans and good vehicle are more likely to be utilised by just the owning business (with fleet rental a notable exception), whereas the purpose of coaches, buses and taxis is to provided passenger transport, so these modes will feature in both the fleet (of the owning businesses) and the usage (of the businesses that utilise them) fields.

The categorisation into direct and indirect emissions is also important when considering abatement measures. For technical abatement measures, the vehicle owners are likely to have greater scope to drive the take-up of these measures than the users. However, behavioural measures will apply to the both owners and users of the vehicles equally.

2.3.3 Results

SMEs are estimated to be responsible for about 37 Mt CO₂ of transport related emissions in the UK, when assessed on a 'direct' basis. This only includes emissions from vehicles owned by SMEs, and does not include emissions arising 'indirectly' from vehicles not owned by SMEs. This will therefore represent an underestimate of the total emissions associated with SMEs, for example, by not including commuting in employee owned vehicles. However, it is difficult to include indirect emissions in the overall estimate without introducing the potential for double counting.

The table below shows the estimated direct emissions from the sector, subtotalled by mode of transport.

Table 2-4: Transport CO₂ emissions from SMEs by mode (2008 data)

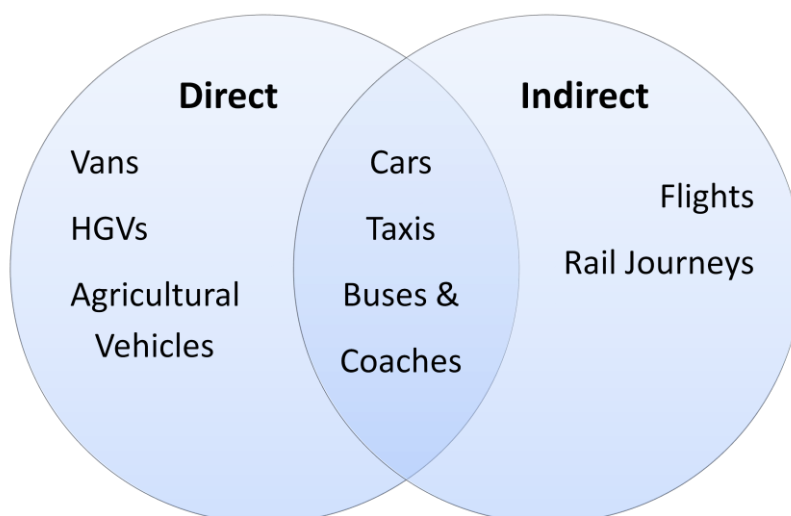
Category	Direct kt CO ₂
HGV	16,860
Light commercial vehicles	7,510
Agricultural vehicles	4,416
Passenger cars	4,305
Bus and coach	2,684
Taxis	1,169
Two-wheelers	-
Civil aviation (domestic)	-
Passenger rail travel	-
Grand total	36,943

HGVs contribute the largest amount to direct emissions. This is influenced by their high overall emissions, and the fact that all vehicles are assumed to be business owned – rather than HGVs being disproportionately popular for SMEs. The contribution from Light Commercial Vehicles, agricultural vehicles, taxis, buses and coaches is however influenced by a high level of SME ownership. The contribution of SMEs to total passenger car emissions is less significant, although this remains an important source of direct emissions from SMEs.

Direct emissions from aviation and rail emissions are assumed to be zero on the basis that the owners and operators of these modes are unlikely to be SMEs. Similarly, two-wheelers are dominated by private use rather than business use.

A preliminary estimate has been made of the indirect emissions that can be associated with SMEs. As discussed above a proportion of these emissions will overlap with the direct emissions. This is illustrated in the diagram below¹⁰.

¹⁰ Note, this diagram is specific to SMEs. For example, if looking at businesses as a whole then flights and rail emissions can also be considered direct.

Figure 2-7: Coverage of direct and indirect emissions from SMEs, by mode of transport

In the diagram above, the direct section shows vehicles of which a proportion are likely to be SME owned. For certain vehicles within this group (e.g. HGVs) indirect emissions (from passenger transport¹¹) are assumed to be zero.

The indirect section includes activities whereby the vehicles are not necessarily owned by SMEs, however, emissions can be allocated 'indirectly' through travel carried out by SME employees. For certain modes none of the transport service providers are expected to be SMEs. Hence, direct emissions from SME are assumed to be zero. This circumstance is only assumed to be applicable to aircraft and trains.

The area of overlap between the indirect and direct sections is where SMEs can be attributed emission on both a direct and indirect basis. This relates to vehicles, such as buses and taxis that can be owned by SMEs but also used by other SMEs for business travel. This is the area where the double counting of emissions is most problematic.

Two wheeler emissions are dominated by private use, and given their very small overall contribution, the SME proportion has been approximated to zero for both direct and indirect emissions.

The table below shows the estimated indirect emissions from the SME sector, subtotaled by mode of transport. The results above represent 2008 emissions, which is the most recent year for which GHGI data are available.

¹¹ In practice, HGVs may constitute indirect emissions to SMEs through supply chain emissions e.g. by delivering products used by SMEs. As described above the current analysis of indirect emissions is restricted to passenger transport, so these emissions are excluded.

Table 2-5: Transport CO₂ emissions from SMEs by mode (2008 data)

Category	Indirect SME kt CO ₂
Passenger cars	18,294
Bus and coach	666
Passenger rail travel	349
Civil aviation (domestic)	146
Taxis	85
Agricultural vehicles	-
Two-wheelers	-
HGV	-
Light commercial vehicles	-
Grand total	19,540

Overall, indirect emissions are just over half the total for direct emissions (53%). Passenger cars dominate, with significant emissions from both commuting and business use. These emissions are over 4 times larger than the estimated emissions from company owned vehicles.

Bus and coach and taxi emissions are much lower, in part reflecting the relatively small amount of journeys associated with business purposes. Aviation and Rail emissions are also small, reflecting the smaller overall contribution of these modes to total UK transport emissions.

These results highlight the importance of including commuter and business emissions, particularly from passenger cars, in measures to target emissions reductions from SMEs

Confidence levels

Confidence in the results from the analysis of transport related emissions is demonstrated qualitatively in the table overleaf.

The overall emissions from different modes of transport are the most accurate component of the calculation. For most modes, the proportion of the emissions that relates to business travel was either self explanatory or supported by DfT's National Travel Survey (NTS). For example, HGVs or airport vehicles are assumed to be never used for personal travel, and van and passenger car percentages are well documented in the NTS. Business related percentage for passenger air travel is taken from surveys of people at the most popular airports.

The lowest certainty lies in apportioning of the direct business related emissions to SMEs. Importantly, for the two largest contributors, passenger cars and HGVs, we have a good level of confidence in the percentage attributable to SMEs. For HGVs the estimate was based on market research of the HGV sector. Business travel in passenger cars and business rail travel were both split by the percentage of employees who work for SMEs: 59%. This does not account for possible differences in distance travelled by employees of SMEs and larger organisations. It could be that overall, larger companies have a larger catchment area and therefore employees have a longer commute, or travel further to meet clients or colleagues – this was assumed not to be the case.

Light duty vehicles have been apportioned to SMEs based on AEA estimates using experience from the Van Best Practice programme. Bus and coach percentage has been provided using weighted averages of estimates of data from trade association contacts. Other percentages are based on the views of experts within AEA.

Table 2-6: Confidence in business related and SME-related percentages

SME responsibility	Category	2008 kt CO ₂	Business owned %	SME %	SME kt CO ₂
Direct	Passenger cars	70,912	10%	59%	4,305
	HGV	23,474	100%	72%	16,860
	Light duty vehicles	15,651	96%	50%	7,510
	Bus and coach	4,851	100%	55%	2,684
	Agriculture - mobile (and stationary) combustion	4,648	100%	95%	4,416
	Civil aviation (domestic)	1,611	100%	0%	-
	Passenger rail travel	1,258	100%	0%	-
	Taxis	1,169	100%	100%	1,169
	Two-wheelers	620	0%	0%	-
Total - direct					36,943
SME responsibility	Category	2008 kt CO ₂	Business use %	SME %	SME kt CO ₂
Indirect	Passenger cars	70,912	43%	59%	18,294
	HGV	23,474	0%	0%	-
	Light duty vehicles	15,651	0%	0%	-
	Bus and coach	4,851	23%	59%	666
	Agriculture - mobile (and stationary) combustion	4,648	0%	0%	-
	Civil aviation (domestic)	1,611	45%	20%	146
	Passenger rail travel	1,258	47%	59%	349
	Taxis	1,169	12%	59%	85
	Two-wheelers	620	0%	0%	-
Total - indirect					19,540

Key

	AEA estimate
	Survey data
	National survey or database

3 Abatement potential

Chapter summary

Cost-effective energy efficiency measures have the technical potential to reduce emissions from unconstrained sector by an estimated 7.8 Mt CO₂/year. This represents an annual energy savings of 28 TWh, and an associated energy bill saving of £1.2 billion.

The majority of the abatement potential relates to public and commercial sector buildings, representing around 7.2 Mt CO₂/year by 2020. This includes measures such as more efficient boilers, heating and lighting controls and behavioural measures.

A proportion of this technical abatement potential will be taken up in response to existing policies and other drivers. Therefore, the remaining cost-effective abatement potential in 2020 will be lower than this estimate of the current potential. It is estimated in Chapter 4.

Alternative energy supply technologies, including conventional gas-CHP and renewable heat and electricity have the potential to deliver significant reductions in emissions from the sector. While much of the current potential is not cost-effective without further Government support, we estimate in the region of 1.2 Mt CO₂ of abatement may be delivered in the unconstrained sector by 2020, before the impact of recent support policies.

For those industrial activities that form part of the unconstrained sector we estimate a cost-effective abatement potential of around 0.6 Mt CO₂ in 2020, equivalent to around 5% of industrial unconstrained sector emissions.

For both the public and commercial, and the industry sectors, the estimated cost-effective potential is relatively insensitive to both the discount rate, and also a carbon price of up to £100/t CO₂. This indicates that few measures are on the margin of being cost-effective.

In the transport sector, the grand total of savings achievable through technological measures is 4.5 Mt CO₂ or 12% of SMEs' total direct carbon footprint from transport. However, from a social perspective none of this potential is currently cost-effective at current energy prices. This relates to emissions from vehicles owned by organisations in the unconstrained sector.

3.1 Introduction

Chapter 2 outlined the estimated energy use and carbon emissions associated within the organisations within the unconstrained sector. This Chapter provides an estimate of the potential abatement that can be delivered by energy efficiency and alternative energy supply measures within the sector, and the associated cost of abatement. This includes an analysis of the abatement delivered at different carbon prices.

3.2 Development of a marginal abatement cost curve

The main output from the analysis is a marginal abatement cost curve (MACC). The MACC provides a ranked ordering of abatement measures based upon their cost-effectiveness of delivering reductions in emissions in a given year. The MACC is a powerful tool for understanding the total level of abatement that can be delivered from energy efficiency and alternative energy supply measures within the sector. It also provides an understanding of the relative costs of the individual measures. It can therefore be used to determine the marginal cost of delivering a given level of emissions abatement.

Underpinning the MACC is detailed data on the cost and abatement potential of the individual measures, assumptions with respect to the uptake of measures in response to existing policies and

other drivers, and adjustments for measures interaction. The values used to generate the MACC are based on an estimate of the cost and the abatement potential of the measures that is considered representative of the sector as a whole. The MACC does not provide a precise estimate of the cost or abatement of a given measures in a specific circumstance. For certain measures the cost and/or abatement potential may vary significantly from one setting to the next depending upon e.g. the age of the building, or its occupancy levels. It is therefore important that the results from the MACC are viewed with the resolution of the analysis in mind – in this case, a relatively high-level sectoral assessment.

The abatement potential has been assessed for the public and commercial, industry and the transport sectors separately, and the results have then been combined. Each of the sub-sectors has been assessed using different models, but as far as possible the analysis has been underpinned by consistent assumptions. Specifically, the analysis has been carried out in accordance with the Inter-departmental Analyst Group (IAG)¹².

The MACC models have been developed to represent a series of alternative scenarios, and to reflect decisions from both a commercial and social perspective. This takes into account variations in:

- Energy prices.
- Carbon prices.
- Discount rates.
- Hidden and missing costs.

The outputs from the MACC analysis can also be further manipulated to provide insights relevant to policy development. This includes, for example, separating out the cost-effectiveness of abatement of traded emissions (i.e. emissions from electricity consumption which are covered by the EU ETS) from non-traded emissions (i.e. direct fuel combustion outside of the EU ETS).

3.3 Public and commercial sectors

All previous estimates of the abatement potential from the public and commercial sector derive from one primary source: BRE's Non domestic energy and emissions model (N-DEEM). N-DEEM was developed as part of large programme of research on the energy use within the UK building stock that took place in the late 1980s and 1990s. It therefore benefits from extensive research investment – albeit research that is now quite old.

The 'model' is actually a collection of datasets and procedures that enables, based upon the scaling up of sample data, an assessment of the energy use within different segments of the UK non-domestic building stock. When combined with a dynamic simulation model, the sample data can be used to estimate the potential energy savings from a range of abatement measures across a range of hereditaments. The results can also be then scaled to the UK level.

The abatement measures are largely technical energy efficiency measures, although certain behavioural measures relating to energy management are also included. The main measures categories are shown below.

¹² Valuation of energy use and greenhouse gas emissions for appraisal and evaluation. January 2010

Heating & cooling	Heating - most EE boiler Heating - programmable thermostats high Heating - TRVs fully installed Heating - more efficient air-conditioning	Insulation	Most EE double glazing (replace double) Most EE double glazing Most EE external wall insulation Most EE flat-roof insulation Most EE pitched-roof insulation
Lighting	Lights - HF ballast Lights - IRC tungsten-halogen - spots Lights - metal-halide floods Lights- most EE replacement 26 mm Lights- most EE replacement 38 mm Lights- most EE replacement tungsten	Behavioural	Computers - energy management Heating - reducing room temperature Lights - turn off lights for an extra hour Monitors - energy management Fax machine- energy management Photocopiers - energy management Vending machines - energy management Heating - optimising start times
Lighting controls	Lights - basic timer Lights - light detectors Lights - sunrise-sunset timers Presence detector Stairwell timer	Equipment	Most EE freezer Most EE fridge-freezer Most EE fridge Most EE monitor/pc
Other	Variable speed drives Compressed air Motor - EE motor		

A key issue that needs to be taken into account when aggregating the abatement potential from individual measures is how to take into account measures interaction. This relates to the fact that the installation of certain abatement measures (e.g. more efficient heating) will reduce the potential savings that can be delivered by subsequent abatement measures (e.g. insulation). This is taken into account within N-DEEM by presenting the results as two scenarios, one that represents 'individual measures in isolation' i.e. the estimated savings with no other abatement options in place, and one that represents 'measures combined' i.e. the estimated savings assuming that all other relevant measures have already been applied. The latter scenario will provide a lower bound estimate of the savings, and will underestimate the savings in the short run. This 'measures combined' scenario has been used in the current analysis to provide a more conservative assessment of the abatement potential.

The analysis carried out within N-DEEM is restricted to the current building stock; it does not consider new build but looks at the savings still available in the current building stock in future years. Additional modelling is therefore required to account for emissions associated with new buildings. Since the energy efficiency of new buildings are specifically covered by the Building Regulations policy, measures targeting new build are not considered further in this current analysis.

3.3.1 The model and assumptions

The original aspiration of this study was to update and validate the primary input data that are drawn upon within N-DEEM, thereby allowing an updated estimate of the abatement potential of the sector, using N-DEEM, while ensuring consistency with the previous model estimates. However, it became apparent shortly into the project that this approach would not be feasible. Certain elements of the N-DEEM framework no longer function and further work would be required to just re-run the analysis that was performed previously. It was therefore necessary to modify the planned approach.

Since it was not possible to validate and update the model inputs the methodology instead focussed on the model outputs. This can be described in terms of the following steps:

1. Estimate the abatement potential within the unconstrained sector based on the most recent outputs from the NDEEM model, as used in the report for the Committee on Climate Change in 2008.
2. Check the accuracy and robustness of the outputs from the N-DEEM modelling against estimates of the abatement potential in the non-domestic building stock from alternative sources.
3. Update the outputs from the N-DEEM model on the basis of the findings from step 2.

Current N-DEEM estimates

The most recent analysis of the abatement potential from the unconstrained sector (BRE, 2009) was based upon the outputs from N-DEEM, and the associated Marginal Abatement Cost Curve (MACC) tool that was produced by BRE, and updated by AEA, for the Committee on Climate Change in 2008. The MACC tool provides an estimate of the costs and overall savings from a range of abatement measures¹³ when applied to the UK non domestic building stock. The results from this analysis were also used in a study by Element Energy (2009) that reviewed and updated the penetration of the abatement measures in the MACC tool to 2020.

The results from the MACC tool are presented for individual abatement measures, but on an aggregated basis. For example, each of the abatement measures is associated with a total energy saving and cost, but no information is provided on the number of measures applied, or the take-up of measures by different sectors or building types. The one area where the results are disaggregated is with respect to the cost-effectiveness of the measures. Aggregated results are presented for all instances when the measures are cost-effective (CE), based on the specified discount rate, and also separately for all instances where the measures are not cost-effective. The sum of the CE and non-CE savings represents the technical potential for each measure type.

In the previous work the abatement potential from the unconstrained sector was estimated by disaggregating the results from the N-DEEM model according to the relative proportion of total energy consumption that has been attributed to the unconstrained sector. This effectively assumes that the abatement potential for organisations within the unconstrained sector is the same, for a given sub-sector and energy end use (e.g. lighting, heating), as for organisations in the constrained sector. The results from this analysis are elaborated in Appendix 3.

Accuracy and robustness of the previous N-DEEM estimate

The detailed approach that was used to review the accuracy of the outputs from N-DEEM is described in Appendix 3. In summary, the review found that while the results from N-DEEM cannot be compared directly with those from other sources due to e.g. difference in scope and methodology, they are broadly consistent when expressed in terms of the relative abatement potential (i.e. the percentage of current energy use that can be technically abated by cost-effective measures). It was not possible to provide a comparison on an absolute basis.

The N-DEEM results tend to provide a more optimistic assessment of the abatement potential when compared to the results from site surveys. However, this is not surprising since the N-DEEM analysis works by examining all possible abatement options at a given site, whereas the site surveys typically focus on a much shorter list of the most favourable options. While you would expect that this short list would include those measures with the greatest potential, it is also logical that this will deliver a smaller estimate of the abatement potential than the N-DEEM approach. This provides some confidence that the overall cost-effective abatement estimated by N-DEEM is not overly optimistic.

The N-DEEM results also present a more favourable assessment of the cost-effectiveness of the abatement measures than similar results from the Carbon Trust site surveys. While some of this can be put down to methodological differences (e.g. energy price assumptions) it is not clear if this can explain the discrepancy in full.

The mix of measures types that N-DEEM predicts will deliver the cost-effective abatement potential are comparable to the mix of measure types predicted elsewhere. Behavioural energy and carbon management measures (e.g. reducing room temperature, turning off lights) are an important measures group, along with control measures (e.g. heating controls, lighting controls). These are all relatively low cost measures, with short pay back periods. Other important measures include more efficient boilers and air conditioning. At a high level the results suggest broad consistency in those measures types that are expected to deliver the majority of the cost-effective savings.

Further examination of the individual technical and behavioural measures suggests that the N-DEEM analysis may overestimate the potential from some measures, but underestimate the potential from

¹³ In the analysis that was carried out for the CCC, Combined Heat and Power (CHP) was removed from the list of measures and assessed separately by AEA.

others. The N-DEEM MACC also has some limitations in terms of the coverage of the measures listed. Some of the measures that are captured in the model are not necessarily representative of the latest technologies on the market, and some technologies e.g. voltage optimisation, are omitted. This limits the accuracy of results at the level of the individual measures.

While certain measures were introduced as part of its most recent update, N-DEEM is also limited in its coverage of alternative energy supply technologies. However, since most of these technologies are not cost-effective without financial support then this will not affect the estimated cost-effective potential greatly¹⁴.

A further limitation of N-DEEM is its ability to examine the abatement potential within different sub-sectors of the non-domestic stock. Since the model draws upon a relatively limited sample of hereditaments, it is not able to accurately estimate the potential for individual sub-sectors of the stock, as the sample sizes are too low. Data from the site surveys suggest the relative abatement potential is similar for the different sub-sectors that make up the public and commercial sector, particularly when compared to industrial buildings. However, this is still considered to be an area of large uncertainty with a number of studies highlighting the heterogeneity of the non domestic stock (in comparison to domestic buildings say) as being a major barrier to accurate modelling of the abatement potential.

Finally, analysis of site survey data by the Carbon Trust suggests that the cost-effective abatement potential within smaller organisations, as a proportion of the total energy bill, is greater than for larger organisations. This suggests that previous estimates of the abatement potential from the unconstrained sector – by assuming the potential is unrelated to the organisation size - may have underestimated the total abatement potential of smaller sites.

Updating the abatement potential

Following the review of the N-DEEM MACC model a number of options were considered for revising the estimate, including using the current model, updating certain elements of the model that were considered particularly limited, and creating a whole new model (albeit one that was much more simple). The preferred approach, and the one used in this study, was to use a modified version of the current model. While it is apparent that N-DEEM has some limitations, it is not clear that it would be possible to derive a more robust estimate of the abatement potential from the sector within the resources available to this study.

For example, an alternative approach would be to develop a MACC 'bottom-up', using data from the individual site surveys and then scaling these data up to the full population. This was the approach used by Camco (2009) in an assessment of the abatement potential from public sector buildings in England¹⁵. While this approach has certain merits, for example, it draws upon more recent data and a large sample of sites, it also has certain limitations. The site surveys that are available do not typically record detailed information of the building stock and usage – limiting the robustness of any scaling of survey results to a UK level. This is reflected, for example, in the use of correction factors as part of the Camco analysis, which were largely based on expert judgement rather than empirical analysis. It also not clear if a bottom-up approach can ensure the same level of consistency in how the measures are evaluated. On this basis we conclude that this bottom-up approach is unlikely to provide an assessment of the abatement potential that is necessarily more accurate or robust than the N-DEEM MACC.

What is clear is that no one method is perfect and both have limitations – particularly when applied to a sector such as the non-domestic building where the stock and energy use characteristics are so heterogeneous. Furthermore, both approaches are limited by a lack of detailed up-to-date audit data on the current energy use characteristics of the stock¹⁶ and the interaction of different abatement measures when applied to the stock¹⁷. This is a major gap in the evidence base which will require a new programme of data collection to realistically be overcome.

¹⁴ However, the recent introduction of policies to provide support for small scale renewable technologies will have an important impact on the take-up of these measures.

¹⁵ In practice the overall level of cost-effective abatement was very close to the result from the 'top-down' N-DEEM analysis

¹⁶ While the Carbon Trust bottom-up dataset is an important source of information, it does have certain limitations. Importantly no data is collected on the characteristics of the building stock (such as floor areas etc) which limits the usefulness of this data for replicating different building types.

¹⁷ In particular, economy wide interactions between energy efficiency measures and alternative energy sources

Accepting the above limitations, the existing N-DEEM MACC tool was used in the current study with the following modifications:

- Updated estimate of the energy use from the unconstrained sector, reflecting the improved estimate of the abatement potential from the unconstrained sector.
- Updated input data to ensure consistency with the latest IAG guidelines.
- Updated technology penetration curves to reflect the latest analysis of the business-as-usual uptake of abatement measures to 2020.
- Enhancing the functionality of the MACC model to enable alternative scenarios to be examined, and allow input assumption to be easily updated.
- Inclusion of a sensitivity analysis around the relative abatement potential from smaller organisations.

The scale of energy savings that can be delivered by individual measures, and the associated costs, are largely unchanged from the previous version of the model. Due to the limitations in the primary data on measures described above, the results should be considered more robust at the level of the broad measure types, than at the level of specific technologies. For alternative energy supply technologies, the analysis has drawn upon more detailed abatement cost models that have recently been developed to support policies in this area.

- **Input assumptions**

The input assumptions for the model, including fuel prices and emissions factors, are consistent with the latest IAG guidelines for the valuation of energy use and greenhouse gas emissions in policy appraisals and evaluations.

- **Technology penetration rates**

The original N-DEEM model estimated the cost-effective potential in the future by projecting the business-as-usual uptake of measures (i.e. what would happen without further policies). The projections on future take-up were based on a best estimate at the time, taking into account the historical take-up of measures, and assumptions about future take-up. These assumptions were reviewed in detail and updated as part of a study by Element Energy (2009). As part of the update a more sophisticated methodology was developed for modelling uptake. This took into account, among other things, the frequency of replacement of the measures, the influence of payback on purchasing decisions and the impacts of existing policies. The updated business-as-usual penetration curves that were developed by Element Energy have been used here since they represent the current best estimate.

While the Element Energy business-as-usual penetration curves include certain policy impacts they do not include policies introduced as part of the 2009 Low Carbon Transition Plan, or subsequently. Therefore, the uptake of energy efficiency technologies might be expected to be more rapid than assumed in the current penetration curves. It was not possible within the scope of the current study to update each of the individual technology penetration curves to reflect these recently introduced policies. A more simplistic top-down approach was therefore used where the latest outputs from the MACC model were adjusted to allow for the impacts of the policies, based on the overall carbon savings reported for the policies. This analysis is presented in the next Chapter.

- **Realistic potential**

The output from the N-DEEM MACC model is an estimate of the technical abatement potential. This represents an indication of the total potential that can technically be applied to the stock to deliver emissions abatement. It does not necessarily represent the potential that can realistically be achieved, for example, by taking into account the replacement rate of the technologies – so whether the abatement potential can be realistically achieved within the timescale. On this basis, there is a risk that the outputs from the analysis might represent an overestimate of what might be realistically achieved as a result of policy intervention. Analysis by Element Energy (2009) suggested that a realistic potential, based upon the delivery of additional potential policies, might be 70% of the technical potential. The results presented below have not been scaled back to reflect this adjustment.

- **Stock modelling**

The N-DEEM MACC model is not a dynamic stock model. It is based upon a snapshot of the building stock at a given point in time, with the only dynamic element the penetration of energy efficiency technologies within the stock. Ideally the model would also take into account changes in the stock over time, including changes in the usage of buildings (e.g. occupancy) as well as demolition and rebuild. However, this is not a current function of the model. Including the impacts of demolition would act to reduce the abatement potential available in 2020. However, projected increases in building occupancy might offset this partly by increasing energy use and the potential energy savings from abatement measures. These dynamic factors should be included in future model developments.

- **Hidden and missing costs**

One of the arguments often cited for the reasons why organisations may not take up cost-effective abatement measures is due to the incidence of hidden and missing costs. These include costs that are not immediately related to the direct financial flows associated with the measure itself, but which nonetheless arise in the overall process of undertaking the investment. These may include, for example, management time, investment appraisal and other decision-making processes, information gathering and analysis, and negotiation and procurement. It could be argued that these costs are more important for smaller organisations that have fewer resources to support these types of activities. To allow for these costs, the MACC model includes an estimate of hidden and missing costs for each of the relevant measure types based on previous analysis by Enviro (2006).

- **Abatement from smaller organisations**

Analysis of data collated by the Carbon Trust (see Appendix 3) from its sites surveys suggests that there is greater savings potential, when expressed as percentage CO₂ savings, in small organisations (defined in terms of energy bill) than in larger organisations. In each of the three sub-sectors analysed, lower percentage savings were identified in the sample of 'large' organisations, than for organisations in the medium energy bill size bands. Organisations in the 'small' size band had further abatement potential still. While it has not been possible to validate this conclusion with results elsewhere, the findings are potentially important for the unconstrained sector where a large proportion of the organisations are small in size. The weighting of the abatement potential according to size of organisation has been included as a sensitivity analysis in the MACC tool. The results presented below take a conservative approach assuming no weighting is applied to smaller organisations.

- **Alternative energy supply technologies**

There is a great deal of potential to reduce emissions from commercial and public sector buildings using alternative energy supply technologies. These include renewable heat technologies (such as heat pumps, biomass boilers, solar heating) and also renewable electricity technologies (such as wind turbines, photovoltaics, small scale hydro). In addition, gas-fired CHP can also deliver emissions reductions relative to the conventional heating technologies.

The abatement potential from these technologies has recently been subject to a large amount of research and modelling to support Government policies¹⁸. We have not sought to replicate this research in the current analysis, since these are detailed studies in themselves. Instead we have drawn upon the results of the previous work to inform the analysis of the abatement potential within the unconstrained sector¹⁹.

As with the energy efficiency measures, the realistic take-up of technologies is an important consideration when assessing the abatement potential from alternative energy supply technologies. This should ideally take into account practical issues associated with the uptake of measures such as technology replacement cycles, as well as behavioural and market factors such as consumer choices

¹⁸ In particular, work to inform the RHI and the FiT for renewable electricity.

¹⁹ While this means that we do not have the same flexibility as with the energy efficiency models to analyse alternative scenarios, from a policy perspective it is reasonable to assume these technologies are less likely to be subject to new policies – given that major policies have only recently been introduced. On this basis it is more important to understand the impact of these recently introduced policies on the take-up of alternative energy technologies in the unconstrained sector.

and supply industry constraints. These factors have been taken into account, to varying degrees, in the previous modelling work. We do not attempt to un-pick the influence of these factors here, but simply state that the estimates of the cost-effective abatement potential include these wider considerations²⁰. Further details on the assumptions used can be found in the original reports

The savings identified from the implementation of these technologies can be considered separate to the energy efficiency savings described previously. However, it is not so straightforward that the savings can simply be added together. The large scale take-up of low carbon energy technologies will potentially reduce the level of carbon savings delivered by energy efficiency technologies and vice versa. There are also some direct overlaps between the savings estimated from alternative energy supply technologies and the measures in the NDEEM MACC model. These overlaps are discussed in more detail in the next Chapter.

3.3.2 Results – energy efficiency measures

As described above, the abatement potential from energy efficiency measures have been assessed using a modified version of the N-DEEM MACC model. The updated model allows for certain parameters to be changed, such as energy prices or discount rates, which then influences the overall results. The results presented below are based upon the latest DECC energy prices projections (Central Scenario), use a social discount rate of 3.5% to value costs and benefits arising in the future, and do not include hidden or missing costs.

The MACC model estimates the technical abatement potential from energy efficiency measures in the base year and the remaining technical potential, taking into account the business-as-usual uptake of abatement measures, in the target year – in this case 2020. The business-as-usual penetration of measures takes into account certain policies in place prior to the Low Carbon Transition Plan, **but not policies introduced more recently**. An adjustment for policies introduced more recently is made in the next Chapter.

We estimate a technical abatement potential, in commercial and public sector buildings within the unconstrained sector, from measures that are currently cost-effective, of 7.2 Mt CO₂. This represents the annual savings that could be delivered in 2020 from the implementation of those cost-effective measures that are currently available in the base year (2010). These measures are shown in Figure 3-1 below. The take-up of these measures would deliver an annual energy savings of around 26 TWh, and an annual energy bill saving for the sector of around £1.1 billion²¹.

A proportion of this abatement potential will be taken up in the business-as-usual scenario as a result of existing policies and other drivers. This business-as-usual take-up is equivalent to around 2.6 Mt CO₂ of annual abatement by 2020. This estimate assumes, based on the previous analysis by Element Energy (2009):

- Due the requirements of the 2006 Building Regulations, the replacement of energy efficient boilers, air conditioning and glazing are mandatory where cost-effective in the model.
- Uptake of energy efficient boilers occurs at the replacement rate. The full potential is virtually achieved by 2020 and represents over a third of the business-as-usual carbon savings.
- A higher penetration of heating controls is assumed than for the previous BRE analysis. Heating controls represent just under a third of the business-as-usual carbon savings by 2020.

We consider that this business-as-usual scenario represents an optimistic estimate on what might be expected in terms of the uptake of certain abatement measures, in the absence of further policies.

Allowing for this business-as-usual uptake, the remaining cost-effective abatement potential in 2020 is equivalent to 4.6 Mt CO₂/year. Just over half of these savings relate to emissions in the traded sector

²⁰ While the influence of these factors, and other methodological assumptions, will influence the overall comparability of the estimates. Since there is a large uncertainty in the relative proportion of measures that are expected to be taken up by organisations in the unconstrained sector, we consider this inconsistency is acceptable.

²¹ For consistency with the results presented elsewhere the energy bill savings has been evaluated from a social perspective i.e. based upon the variable element of energy prices alone, and not the full retail prices. This therefore represents an underestimate of the financial saving experienced by the end user.

(i.e. from electricity consumption) with the remainder (2.1 Mt CO₂) relating to non-traded emissions. These results are summarised in the table below.

Table 3-1: Cost-effective abatement potential in unconstrained public and commercial sectors

	Cost-effective potential (Mt CO₂)
Base year (2009) abatement potential	7.2
Business-as-usual uptake of abatement measures	2.6
Remaining abatement potential in 2020	4.6

* A proportion of this abatement potential will be delivered by recently introduced policies, as discussed further in Chapter 4

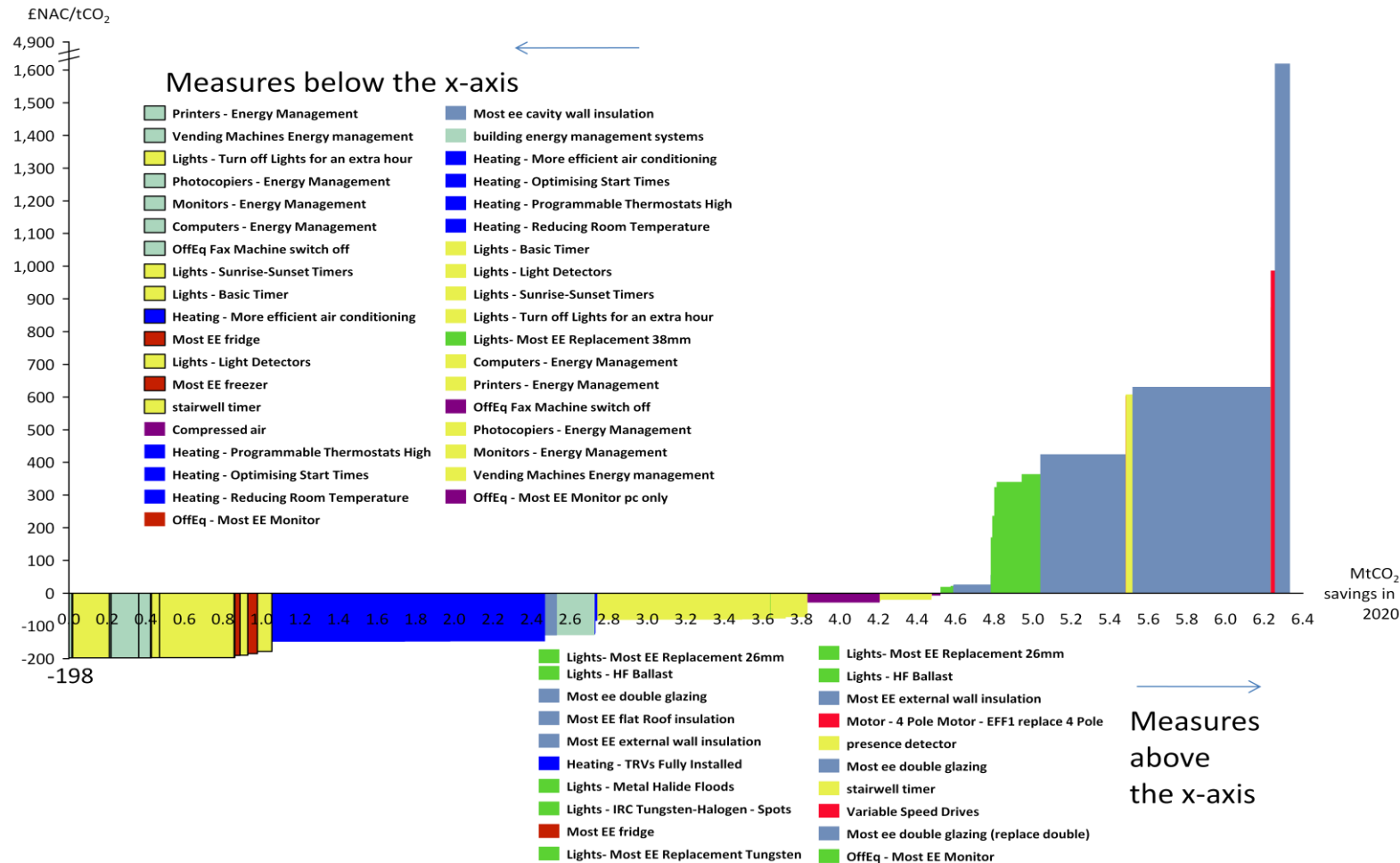
The remaining abatement potential in 2020 can be further described in terms of the composite measures. The influence of the individual measures and their respective cost-effectiveness are shown in the MACC in Figure 3-2 below. Cost-effectiveness is assessed in terms of the net annual cost (NAC) per tonne of CO₂ abated, where the NAC is the sum of the annualised capital cost, the annual energy savings and any hidden or missing costs. Negative values indicated that the annual energy savings are greater than the annual costs. Since the chart represents the remaining abatement potential in 2020, it does not include the abatement that is assumed to be taken up in the business-as-usual scenario.

The most important measures groups for additional abatement in 2020 are; behavioural measures (e.g. turn off lights for an extra hour), heating and cooling, lighting controls and more energy efficient equipment. The measures that perform less well in terms of the cost-effectiveness are insulation measures, and certain lighting measures. It is important to recognise that this reflects the remaining potential in 2020, so for certain technologies the cost-effective abatement potential may have been largely taken up.

Figure 3-1: Marginal abatement cost curve for the unconstrained public and commercial sector in the base year (2010)

Note: certain measures feature twice. This reflects the output from the original NDEEM model where measures were in some instances evaluated to be cost-effective and in other instances not cost-effective, so featured twice to consider both situations. In the current analysis all measures have been included, and have been re-evaluated on the basis of the current model parameters (e.g. energy prices). Consequently some instances where technologies were originally evaluated as not cost-effective now result in the measures being cost-effective, under current assumptions. The technology penetration rates have been applied equally to both cost-effective and not cost-effective measures. While this is a reasonable assumption for measures mandated by regulations, it might assume a faster take-up of not-cost-effective measures than reality for those measures that are not mandated.

Figure 3-2: Marginal abatement cost curve for the unconstrained public and commercial sector in 2020



Note: certain measures feature twice. This reflects the output from the original NDEEM model where measures were in some instances evaluated to be cost-effective and in other instances not cost-effective, so featured twice to consider both situations. In the current analysis all measures have been included, and have been re-evaluated on the basis of the current model parameters (e.g. energy prices). Consequently some instances where technologies were originally evaluated as not cost-effective now result in the measures being cost-effective, under current assumptions. The technology penetration rates have been applied equally to both cost-effective and not cost-effective measures. While this is a reasonable assumption for measures mandated by regulations, it might assume a faster take-up of not cost-effective measures than reality for those measures that are not mandated.

It is also useful to examine the impacts of alternative assumptions on the overall results. In the table below two sensitivities are examined. The first is the choice of discount rate. The results are presented for a range of discount rates to demonstrate the potential rates of return that might be applicable to commercial decision makers. In the commercial scenarios energy prices are valued at the full retail prices, in accordance with the latest IAG guidance. The second sensitivity examines the impact of alternative carbon prices on the cost-effective abatement potential. This price is applied equally to both the traded and non-traded emissions.

Table 3-2: Technical potential for cost-effective emissions reduction from the unconstrained public and commercial sector for a range of carbon prices and discount rate scenarios.

Carbon price (£/t CO ₂)	Social 3.5% (kt CO ₂)			Commercial 10% (kt CO ₂)			Commercial 12.5% (kt CO ₂)			Commercial 15% (kt CO ₂)		
	Total	Non traded	Traded	Total	Non traded	Traded	Total	Non traded	Traded	Total	Non traded	Traded
0	4.61	2.54	2.07	4.63	2.56	2.07	4.63	2.56	2.07	4.63	2.56	2.07
10	4.64	2.57	2.07	4.63	2.56	2.07	4.63	2.56	2.07	4.63	2.56	2.07
20	4.64	2.57	2.07	4.63	2.56	2.07	4.63	2.56	2.07	4.63	2.56	2.07
40	4.68	2.60	2.07	4.64	2.56	2.08	4.64	2.56	2.08	4.64	2.56	2.08
60	4.68	2.60	2.08	4.65	2.57	2.08	4.65	2.57	2.08	4.65	2.57	2.08
100	4.69	2.61	2.08	4.65	2.57	2.08	4.65	2.57	2.08	4.65	2.57	2.08

Overall, the results appear generally insensitive to either the carbon price or change in discount rate. This suggests that few measures are on the margin of being cost-effective. This is shown graphically in Figure 3-2 above, where few measures are just above the horizontal axis. In practice, the values in the MACC represent a mean value that is considered representative of the measure for the given sector. For certain measures there may be a large variation around the mean value so certain measure may be more sensitive than this analysis suggests.

3.3.3 Uncertainties

There are a number of uncertainties in the analysis of the abatement potential from the public and commercial sector. Much of this uncertainty relates to a lack of recent data on the energy use within the stock, at sufficient resolution to enable the abatement potential from energy efficiency measures to be determined with a good degree of accuracy. The data that are available are now quite old and cannot easily be validated by more recent data. This is compounded by the fact that the non-domestic stock is very heterogeneous in nature, which makes it difficult to make any simplifying assumptions with respect to the energy use characteristics of different sectors, or building types. These factors combined mean that the overall results should be treated with greater uncertainty than for other sectors of the economy. That said, comparisons of the modelled abatement potential with the results from individual site surveys suggest a reasonable level of consistency in the cost-effective abatement potential, when the comparison is made at an aggregated level.

3.3.4 Results - alternative energy technologies

The results from the analysis are presented below, for each of the main technology groups.

- **Renewable electricity**

Work to support the Government's Feed-in Tariff (FiT) by Element Energy and Poyry (2009)²² estimated that the total technical potential for sub-5 MW renewable electricity in the UK was 131 TWh/year, excluding gas-fired CHP. This represents the maximum potential across all sectors, and does not include time-dependent constraints such as the maximum growth rate of the industry or a limit on investor demand in a given year. The majority of the identified potential is not currently economic and cannot be delivered without large subsidies.

²² Design of Feed-in Tariffs for Sub-5 MW Electricity in Great Britain. Quantitative analysis for DECC

The Element Energy/Poyry (2009) analysis assumed that in the absence of any further Government support take-up of sub-5 MW renewable electricity by 2020 would be 2 TWh. This effectively represents the cost-effective potential, from the perspective of a private investor²³. The assumed uptake is dominated by large scale technologies such as on-shore wind, hydro power and waste. On this basis we assume that the proportion of this capacity that will relate to buildings-linked renewables in the unconstrained sector will be extremely limited.

The potential renewable electricity that will be delivered under the FiT Scheme is discussed in Chapter 4.

- **Renewable heat**

An estimate of the technical abatement potential from renewable heat technologies is available from work carried out by NERA (2010)²⁴ in support of the Government's planned Renewable Heat Incentive (RHI). Based on the analysis by AEA to support the NERA study we estimate a total potential demand for renewable heat of 466 TWh/year in 2020, across all sectors. Allowing for the fact that certain renewable technologies are only likely to be installed when a boiler is replaced reduces the suitable heat load to 124 TWh/year which includes 101 TWh/year for solar hot water panels which is a discretionary purchase independent of boiler replacement timing. This represents the potential suitable demand, and does not take into account the limits on the available supply of renewable resources or other technical constraints. Furthermore, as with renewable electricity described above, much of this potential is currently uneconomic when compared with conventional technologies.

The NERA (2010) analysis estimated that 2.6 TWh/year of heat capacity would be installed in the public and commercial sector in a business-as-usual scenario i.e. without additional policy support, by 2020. The take-up was assessed from the perspective of a private investor, at a discount rate of 15%. We have estimated the business-as-usual take-up in the unconstrained sector based upon an approximation of the proportion of the heat demand that would be from sites that have an annual electricity demand below the CRC threshold. Since this will include certain sites that may still be captured under the scheme through the parent organisation rule, the resulting factor has been scaled back by 20% so not to overestimate the unconstrained sector. The result is an estimated 0.4 TWh/year of heat, and 0.4 TWh of electricity from renewable CHP. From an abatement perspective, this is expected to lead to a reduction in emissions from the sector of 0.3 Mt CO₂.

The additional renewable heat that will be delivered under the RHI is discussed in Chapter 4.

- **Conventional gas-fired CHP**

The technical abatement potential from gas-fired CHP is based on modelling work carried out by AEA²⁵ for DECC to assess the potential impact of the planned RHI on the take-up of conventional CHP. This takes into account the interactions with the RHI – which will influence the mix of CHP devices and how they will be run. The modelling assumes that all of the economic potential will be taken up, but allows for a range of technical and market barriers.

Overall, the technical potential from CHP is estimated to be 163 TWh/year, across all sectors. This is the same as the potential from renewable CHP, since the technologies are effectively substitutes. Under a business-as-usual scenario, the take-up of CHP is projected to be estimated to be 132 TWh, suggesting a large proportion of the potential is cost-effective with current incentives²⁶.

An estimate has been made of the take-up of conventional CHP in the unconstrained sector under a business-as-usual scenario. As above this draws upon an approximation of the proportion of the heat demand that would be from sites that have an annual electricity demand below the CRC threshold, with a similar correction for sites that qualify through the parent organisation. The result is an estimated potential of 7.7 TWh/year of heat and 10.4 TWh/year of electricity in the unconstrained sector. While the associated reduction in CO₂ emissions will depend on the precise mix of fuels replaced, we estimate an annual emission saving of 0.8 Mt CO₂ in 2020.

²³ A discount rate of 15% was applied

²⁴ Design of the Renewable Heat Incentive NERA February 2010

²⁵ AEA (2010) Interaction between different incentives to support renewable energy and their effect on CHP: the Renewable Obligation and Renewable Heat Incentive.

²⁶ These include a Climate Change Levy exemption for Good Quality CHP

It is important to note that, due to interactions with the RHI, the take-up of conventional CHP will differ (and be lower) with the RHI in place.

Summary

Taken together, we estimate that under a business-as-usual scenario, excluding the FiT Scheme and planned RHI, that alternative energy sources will deliver annual carbon savings of about 1.1 Mt CO₂ in 2020. This figure applies to public and commercial sector sites within the unconstrained sector. Two thirds of these savings will arise from conventional gas-CHP devices.

A proportion of these savings will overlap with the abatement potential from energy efficiency measures described above. Specifically, the emissions savings from conventional CHP assume that a proportion of existing heating systems are replaced by CHP. This will, for example, reduce the potential savings from 'more efficient boilers' in the N-DEEM MACC. Since a large majority of abatement potential from more efficient heating systems in the N-DEEM MACC is assumed to be delivered by 2020 in response to existing drivers, then this overlap relates to the business-as-usual uptake of abatement potential. Therefore, the take-up of alternative energy supply technologies is not expected to reduce the remaining cost-effective potential from energy efficiency measures in 2020.

This estimate of the potential overlap is based on an expert judgement and is therefore associated with a greater level of uncertainty than other areas of the analysis. In general, the overlap between energy efficiency measures and alternative energy sources is an area poorly developed in most of the existing models, and further work is required to improve these estimates.

3.4 Industrial energy use

As described in Chapter 2, a proportion of unconstrained energy use and CO₂ emissions will be associated with industrial energy use. This section describes the estimation of abatement potential from that industrial component.

3.4.1 The model and assumptions

The abatement potential within the industrial sectors has been estimated using the ENUSIM model, a bottom-up model of energy efficiency in industry. The model simulates the uptake of energy efficiency technologies, given assumptions on the base year energy use, the technical detail of the technologies, projections of fuel prices and projections of growth rates. The following paragraphs detail the main modelling assumptions:

Fuel price projections

The simulation model requires projections of delivered fuel prices in three plant size tranches (small, medium, large) for all relevant fuel streams. The prices used are based on price projections derived by DECC/DTI UEP model 38 (UEP38) and are based on the central price scenario. Fuel prices influence the relative and absolute cost-effectiveness of energy efficiency technologies.

Growth projections

The growth projections used in this project originate from UEP 38 and are based on the central price and central growth scenario. The individual higher-level UEP sub-sector growth projections are disaggregated into the following manufacturing areas:

- Food.
- Textiles.
- Paper.
- Chemicals.
- Mineral products.
- Non-ferrous metals.
- Engineering and vehicles.
- Other manufacturing.

The UEP sector's UEP 38 growth projections were extended to the more detailed sub-sector levels required by ENUSIM. To do this the same procedure as used for the CCC CO₂ budget MACC study²⁷ was adopted; however using the revised UEP38 sector projections.

In the current UEP 38 projections there is significant downturn in output projected for 2008-2011; and for this period, the higher-level sector reductions were prorated according to the percentage reduction. After 2011, the original method described above was reverted to. Without this modification to the scaling, it is found that the downturn is not always adequately reflected in some of the individual ENUSIM sub-sectors.

Emission factors

The fossil fuel emissions factors used to develop the cost supply curves are taken from the Interdepartmental Analyst Group (IAG) and for electricity the CCGT emission factor is used to represent the marginal plant.

3.4.2 Methodology

Historically, the ENUSIM model has been used for CCA target setting, the development of the UK EU ETS National Allocation Plan and for estimating abatement in the CRC. Over time, the underlying data in the model have been updated with the aim of maintaining the accuracy of the model.

The model has recently been revised as part of work to inform future CCAs. As part of the updates the model has been amended to increase its transparency and ease of operation. As a component of this review some of the underlying functionality of the model was reviewed. For example, the uptake of each technology over time is defined in the model by S-curves, which are parameterised with an initial trajectory that reflects the current understanding of the outlook for the technology in question. Under the recent review, the S-curves were updated to reflect the view of industry experts or where available the views industry trade associations.

Each industry sector is represented by its sub-sectors and then devices - the processes through which goods are manufactured. For each device, a set of potential energy saving technologies can be applied. Within every time step (annual) of the model, the cost-effectiveness of each technology is calculated. For each industry device, energy saving technologies are fitted to a proportion of the production through that device in relation to the cost-effectiveness of the technology. The technical potential for energy savings at a given time is the difference between the current penetration of each energy saving technology and the maximum potential penetration, across all devices.

To evaluate the technical potential available for the unconstrained sector, we wish to analyse the uptake of technologies from a societal perspective, but also from the perspective of private investors. In the former case, the analysis is carried out without CCL or CCA fuel price effects. Therefore the model is run without CCL/CCA fuel price adjustments.

We use ENUSIM to simulate abatement potential in four different scenarios:

1. Social MACC: This applies a discount rate of 3.5% in accordance with HM Treasury Green Book guidance, and the fuel prices projections are based on the variable element only, as per IAG guidance.
2. Commercial MACC: Discount rates of 10, 12.5 and 15% are applied, depending on the scenario selected. Fuel price projections are based on the retail prices outlined in the IAG guidance, which include the impact of the CCL.

3.4.3 Results

The results of the ENUSIM analysis show that there is total cost-effective technical potential in the industry of around 0.57 –0.59 Mt CO₂ in 2020, equivalent to around 5% of industrial unconstrained

²⁷ AEA, August 2008. Review and update of UK abatement costs curves for the industrial domestic and non-domestic sectors, Final report to the Committee on Climate Change

sector emissions. This represents an annual energy savings of around 2 TWh and an equivalent financial saving of about £132 million.

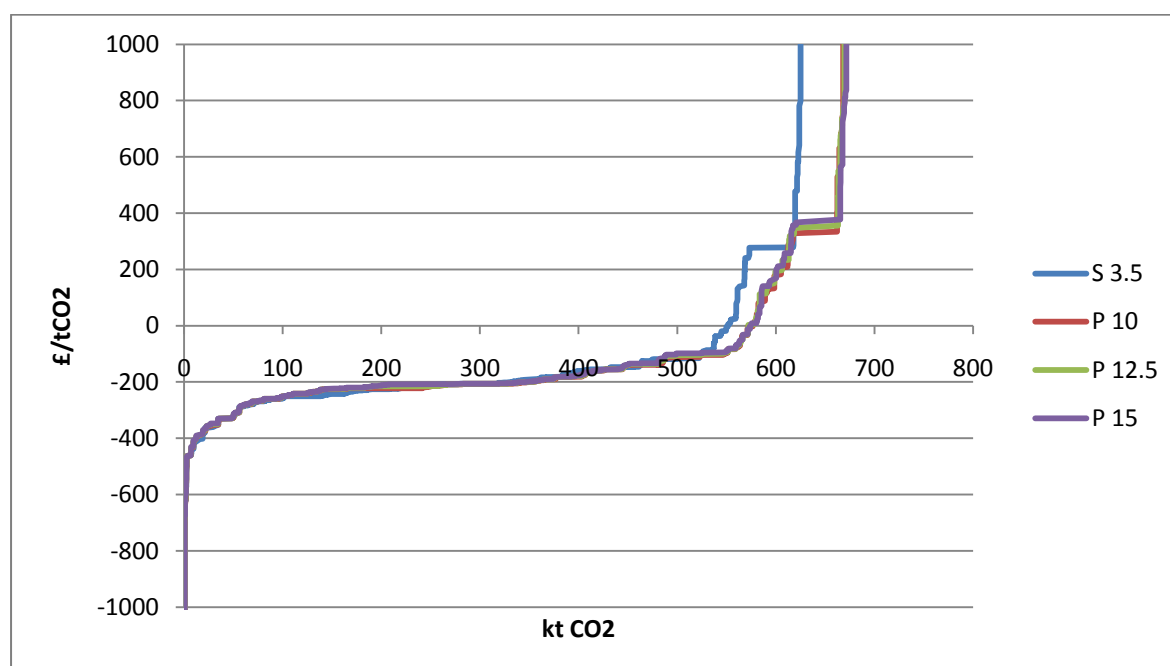
The impact of different carbon prices on the cost-effective abatement potential has also been examined. The results are shown in the figure below.

Table 3-3: Technical potential for cost-effective emissions reduction from the unconstrained industry sector for a range of carbon prices and discount rate scenarios.

Carbon price £/t CO ₂	Social 3.5% (kt CO ₂)			Commercial 10% (kt CO ₂)			Commercial 12.5% (kt CO ₂)			Commercial 15% (kt CO ₂)		
	Total	Non traded	Traded	Total	Non traded	Traded	Total	Non traded	Traded	Total	Non traded	Traded
0	569	296	273	596	299	297	591	298	293	593	299	294
10	570	297	273	596	299	297	597	299	298	596	299	296
20	573	298	275	598	299	298	597	299	298	599	300	299
40	578	300	277	600	300	300	600	300	300	601	301	300
60	578	301	277	601	301	300	601	300	301	602	301	301
100	604	302	302	608	305	303	608	305	303	602	301	301

These results are shown diagrammatically in the figure below, in terms of a composite abatement cost curve.

Figure 3-3: Marginal abatement cost curve for the unconstrained industry sector in 2020



3.4.4 Uncertainties

The principal uncertainties around the calculation of abatement potential in the unconstrained industry sector are:

- The representation of the industry sector within ENUSIM and its appropriateness for the unconstrained industry sector.
- The extent to which the technical potential identified within ENUSIM could be achieved and over what timescale.

On the representation of the industry sector in ENUSIM, the model datasets representing the main industrial processes and energy saving technologies have been compiled and updated in consultation with industry. To the extent that the relevant industry associations have engaged with the consultation process, the model should be representative of the UK industry sector. However, the model has been developed primarily for application to large, energy-intensive industry as covered by CCAs or EU ETS. Therefore the energy saving technologies available to the unconstrained sector may not be well represented by ENUSIM. This is particularly the case for very energy intensive sectors such as steel manufacturing, where the energy saving technologies may include blast or electric arc furnace improvements. Due to the energy demands of blast and electric arc furnaces it is unlikely that energy consumption in the unconstrained steel sector would be through these devices and so the abatement options identified in ENUSIM may not be wholly appropriate. Although this introduces uncertainty into the abatement potential estimate, since the most energy intensive sectors are stringently covered by EU ETS and CCAs the unconstrained sector coverage for those same sectors is small relative to the ENUSIM representation of the whole sector (1 – 2% for steel and non-ferrous metals) and so is unlikely to contribute significantly to the unconstrained sector abatement.

The extent to which the technical abatement potential identified in ENUSIM could be achieved and the timescales over which this may occur is largely determined by the policy and other drivers that are employed to implement technology uptake and the effectiveness of these drivers. A strong policy lever could realise all the emission reductions over a potentially short timescale, while a weak ineffective policy may never realise the emission reductions.

3.5 Overall abatement potential from stationary sources

Taken together cost-effective energy efficiency measures in the public and commercial sector, and the industry sector, have the technical potential to reduce emissions from unconstrained sector by an estimated 7.8 MtO₂/year. This represents an annual energy savings of 28 TWh, and an associated energy bill saving of £1.2 billion²⁸. This is outlined in the table below.

Table 3-4 Annual carbon and energy savings from the implementation from all cost-effective abatement measures available in 2010, by 2020.

	Carbon	Energy saving	
	Mt CO ₂	GWh	£million
Public and commercial sector	7.2	26,445	1,098
Industry sector	0.6	2,028	132
TOTAL	7.8	28,473	1,230

A proportion of this technical abatement potential will be taken up in response to existing policies and other drivers. Therefore, the remaining cost-effective abatement potential in 2020 will be lower than this estimate of the current potential. This remaining potential is estimated in the next Chapter.

3.6 Abatement potential from mobile sources

This section details our approach for the development of a Marginal Abatement Cost Curve (MACC) to assess the abatement options that could be applied to the SME sector. In line with the scoping nature of the transport analysis, the MACC model has drawn upon existing research and assumptions.

There are two types of measure which could reduce SME transport CO₂; technological and behavioural change measures. For technological measures, it was possible to construct a MACC specific to SMEs. This was based on the estimate of the direct emissions that could be allocated to SMEs based on the results in Section 2.3.2. It is assumed that these emissions, because they relate to vehicles owned by SMEs, can be influenced directly.

²⁸ For consistency with the results presented elsewhere the energy bill savings has been evaluated from a social perspective i.e. based upon the variable element of energy prices alone, and not the full retail prices. This therefore represents an underestimate of the financial saving experienced by the end user.

For demand side (or behavioural) measures, the analysis is less straightforward. Existing estimates of the abatement potential from demand side measures frequently use different baseline assumptions, which mean the measures cannot always be directly compared. There is also a question about the scope of emissions covered by behavioural measures, some will relate to vehicles owned by the businesses but other savings will relate to reductions in indirect emissions (e.g. measures targeting commuting and business travel). On this basis it would be misleading to present these measures on a MACC in direct comparison with the technological measures. In this case, we have collated estimates of the potential from these measures, but not compared the measured directly. An estimate has been made based on the proportion of the indirect emissions that are associated with SMEs, although, in practice, some of these measures will also apply to vehicles directly owned by SMEs.

3.6.1 Methodology

Technological measures

The abatement potential for a range of transport technologies was calculated by AEA in 2008 for use in a road transport MACC for the Committee on Climate Change (CCC). The outputs from this analysis are used in the current study.

The use of the CCC analysis provides an estimate of the abatement potential from SMEs that is consistent with the previous analysis from the sector. It also benefits from the previous research on the potential cost and benefits of the different abatement technologies. However, the baseline for the CCC MACC does not include all of the current policies that are in places (see Chapter 4), so some adjustments to the baseline are required to account for recently introduced policies on the abatement potential.

The CCC analysis included a range of alternative scenarios, accounting for the influence of different variables such as energy price assumption, decarbonisation of the grid and technology learning rates. While the alternative scenarios provide useful insights, the current analysis has drawn upon a single scenario – the central scenario of the CCC MACC for all technological options. The cost-effectiveness of measures was taken directly from the final outputs of the transport MACC, as these are independent of application. However, to ensure consistency with the latest Government guidance, energy prices, CO₂ emissions factors and fuel projections, have all been updated. The technology uptake rates are based on the assumptions within the central scenario and are assumed to be unchanged by these variables.

The proportion of CO₂ savings from the technical measures that were attributable to SMEs was estimated pro-rata, on the basis of direct emissions associated with the sector, as indicated in section 2.3.2.

The analysis was restricted to road transport measures, but since road transport represents over 90% of the transport related emissions (when calculated on a direct basis) from SMEs, then the coverage of the abatement potential is high.

Behavioural change measures

Behavioural change measures were not modelled in the previous CCC analysis in the same way as the technological measures. On this basis our approach to assessing the behavioural measures has drawn upon existing published estimates of behavioural measures. An initial literature review identified a wide range of measures, including:

- Green travel plan.
- Organisation carbon calculator.
- Opt-in carbon tax on travel.
- Lower carbon flights.
- Lower carbon hire cars.
- Promotion of teleconferencing.
- Promotion of a reduction in domestic and short haul flights.
- Promotion of public transport and/or cycling or walking.

- Car sharing/pooling.
- Policy on business travel.
- Car parking policy.
- Night time deliveries.
- Best practice advice.
- Driver training.
- Collaborative distribution.
- Driver incentive schemes.
- Telematics.
- Fuel duty changes.

However, it also raised a number of issues associated with the allocation of emissions and difficulties with measures interaction. For example, an 'organisational carbon calculator' may raise awareness about other abatement measures, such as 'low carbon flights'. To help deal with this issue our analysis draws upon previous work by the Commission for Integrated Transport (CfiT) in this area. CfiT (2007) carried out a detailed analysis of a range of behavioural measures, synthesising them into a number of umbrella categories such as Smarter Choices, Eco-driving and measures for Fleets. This limited the interdependencies between the measures, and allowed them to be viewed as discrete options. These options have been used as the basis of the assessment of the abatement potential within SMEs.

3.6.2 Results

Technological measures

Technological measures relating to different modes have been applied to the baseline emissions from Table 2-4. The difference between baseline and measure was then calculated. There are a number of instances of interdependency and among technological measures, as well as cases where technologies are superseded. The transport MACC that was developed for the CCC accounted for such interactions explicitly, and omitted the savings from redundant measures if technology surpasses them in the time period considered.

The cost-effectiveness of the individual measures has been assessed over their entire lifetime, so is unrelated to the time period proposed by the project. Likewise the cost of the measures has been based on the assumptions used within the central scenario of the CCC MACC, and is not influenced by the fact that in this project we are only considering the savings potential for SMEs. Cost-effectiveness forms the y-axis of the MACC.

The savings potential for SMEs forms the x-axis of the MACC. This is based on the relative proportion of the baseline emissions that were allocated to company owned vehicles in the SME sector, as outlined in the table below.

Table 3-5 – SME proportions of emissions savings from technological measures

Vehicle class	% of emissions related to business owned vehicles	% of emissions related to SMEs
Bus and coach	100%	55%
HGV	100%	72%
Light duty vehicles	100%	50%
Passenger cars	10%	59%
Taxis	100%	100%

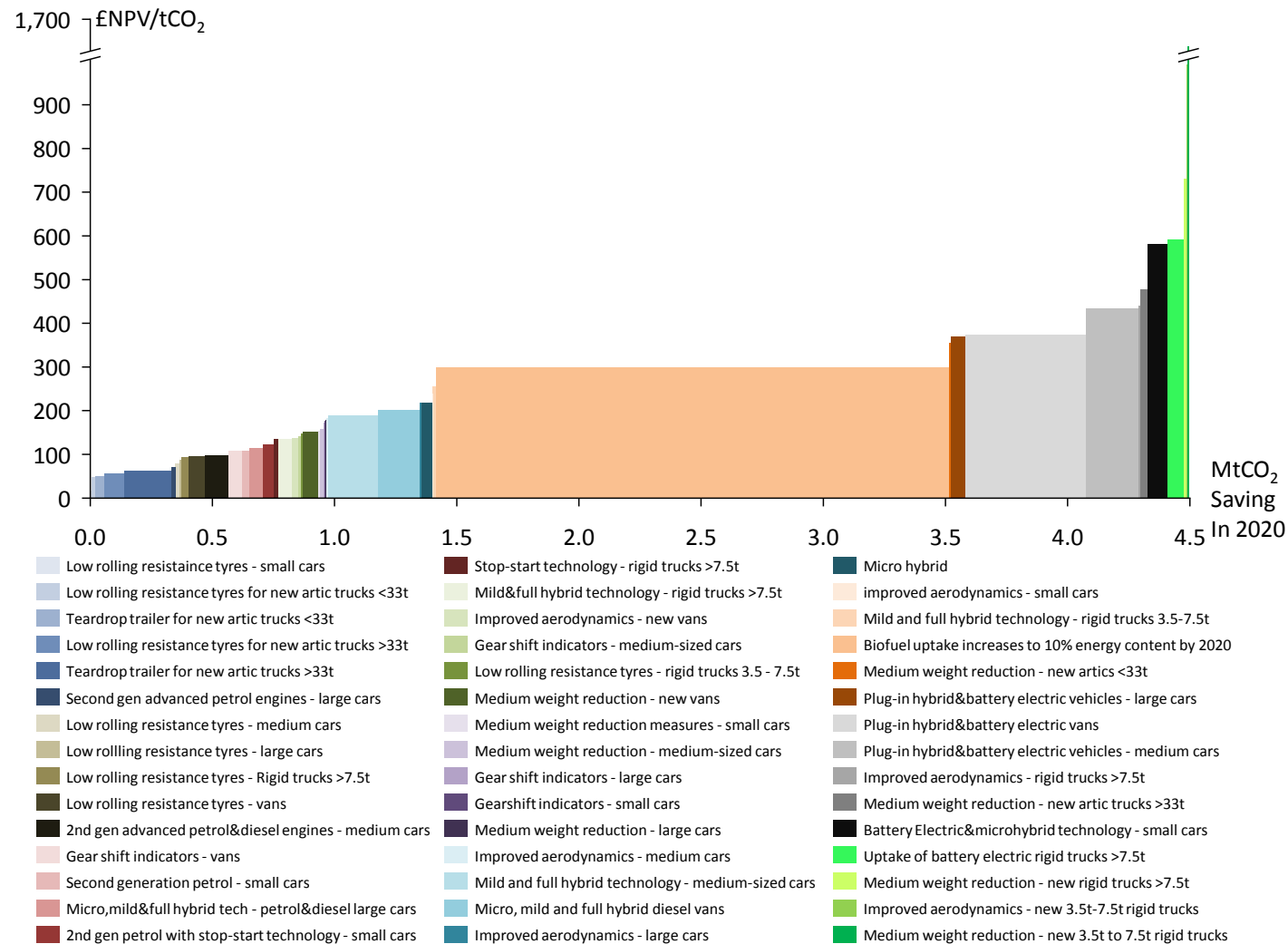
The resulting MACC is shown below. The costs have been assessed from the social perspective, applying a discount rate of 3.5%/year. The values are expressed in 2009 prices as a net present value (NPV), with the savings expressed in terms of the emissions over the lifetime of the technologies. No account is taken for any co-benefits (such as air quality) in the NPV calculations.

The blocks which descend below the x-axis are those which, over their lifetime, will save money. Those which extend above the x-axis have a net cost over their lifetime. In this case, all measures have a net cost over their lifetime, when assessed from a societal perspective. The grand total of savings achievable through technological measures is 4.5 Mt CO₂ or 12% of SMEs' total direct carbon footprint from transport.

In terms of the specific measures, the following conclusions can be drawn:

- Low rolling resistance tyres and teardrop trailers are some of the least cost measures. These are becoming increasingly popular, although it is likely that the take-up to date has been dominated by larger companies.
- In terms of vans, the most effective carbon reducing technology appears to be through hybrids but most significantly plug-in electric vans.
- Biofuels are expected to make substantial savings for SMEs, primarily through HGVs and LDVs due to their relatively high mileages. Passenger cars will also have significant savings from biofuels. The biofuel scenario corresponds to EU Renewable Energy Directive target and is based on biofuel uptake increasing to 10% (by energy content) by 2020 and no second generation fuels taken up.
- Despite only a small proportion of passenger car mileage being direct, plug in hybrid and battery-electric medium-sized cars are predicted to have a large impact, although they will not be cost-effective over their lifetime.

Figure 3-4: Technological MACC for reducing CO₂ from transport by SMEs



Behavioural measures

The assessment of the abatement potential from behavioural measures has been based on a synthesis of published estimates. These are summarised in the table below. Cost-effectiveness data are presented as reported in the source material²⁹ (although carbon converted to carbon dioxide in some cases), with the overall CO₂ savings scaled back to reflect the proportion of the savings that could be made by SMEs. This was estimated using weighted averages of percentages calculated for the total estimate of direct and indirect CO₂ from the SME sector.

In viewing the estimates it is important to recognise that a certain proportion of the emissions savings will already feature in the emissions baseline. For example, SAFED for buses was introduced as part of the Low Carbon Transition plan. Likewise, smarter choices have been supported by DfT and measures have been taken up in a number of Local Transport Plans (LTPs). Without examining these policies in more detail it is not clear what proportion of the savings identified is already included in the current policy framework.

Firstly the cost-effectiveness has been assessed in terms of direct carbon savings from behavioural measures. Consistent with the rest of the document, this includes savings to the owners of the vehicles. These savings cannot be treated as additional to those results presented in the indirect section later on, as the emissions baselines are not mutually exclusive.

Table 3-6: Effects of behavioural measures on direct emissions from transport related to SMEs

Measure	NPV/t CO ₂	Source	Annual kt CO ₂ savings in 2020 from SMEs	Source
Fleets	-£35	Defra (2007)	826	Defra (2007)
SAFED for buses	-£35	Defra (2007)	111	LCTP (2009)
Smarter choices	-£2	Defra (2007)	136	CfIT (2007)
Eco-driving	£6	Harmsen et al. (2007)	297	CfIT (2007)

Table 3-7: Effects of behavioural measures on indirect emissions from transport related to SMEs

Measure	NPV/t CO ₂	Source	Annual kt CO ₂ savings in 2020 from SMEs	Source
Fleets	-£35	Defra (2007)	-	Defra (2007)
SAFED for buses	-£35	Defra (2007)	27	LCTP (2009)
Smarter choices	-£2	Defra (2007)	1,331	CfIT (2007)
Eco-driving	£6	Harmsen et al. (2007)	406	CfIT (2007)

NPV/t CO₂ is a cost-effectiveness measure, and negative values represent a net benefit in these calculations. The NPV estimates presented here include energy savings, but do not include external or ancillary costs or benefits. The measures to reduce CO₂ from fleets, SAFED, and smarter choices all provide a net benefit per tonne of CO₂ in return for the investment.

Cost-effectiveness does not vary when looking at the effects different measures will have on direct and indirect emissions, because it is independent of application.

The differences in carbon savings figures between direct and indirect emissions align with what would be expected:

²⁹ This means that no correction has been made for the price year the savings are presented in, the energy price assumptions or emissions factors. The results are therefore not directly comparable, although the influence of these differences is not considered to change the overall results of the high level comparison.

- For fleets, there are no savings indirectly because there are no indirect related emissions for HGVs and vans.
- The direct savings from SAFED for buses have a larger effect for the bus owners than for the sum of the carbon emissions of individual users relating to their work-related bus trips.
- Smarter choices will reduce the amount of car travel such as commuting and business travel. The reason for the difference between the direct and indirect effects is the difference between company and privately owned passenger cars. A lot of these savings are made from convincing people to cycle or walk in preference to taking the car over short distances.

Overall, behavioural measures have the potential to deliver additional savings over and above the technical options, with certain measures also delivering savings with a net economic benefit. Importantly, behavioural measures are applicable to both direct and indirect emissions from organisations so may have a broader scope than the technical measures. It has not been possible to compare the technical and behavioural measures directly, due to different baseline.

4 Policy impacts

Chapter summary

In Chapter 3, we estimate that cost-effective savings of 7.8 Mt CO₂ are available from the unconstrained sector. However, while organisations in the unconstrained sector are not subject to binding policy instruments, the energy use and CO₂ emissions from the sector will be influenced by other policy initiatives. These include regulations on the energy efficiency of buildings, cars and other energy using products, financial incentives for energy efficiency and renewable energy technologies, and information and advice.

These policies will take up a proportion of the cost-effective abatement potential from energy efficiency measures that was identified in Chapter 3, as well as delivering additional abatement from renewable energy supplies. After taking into account these policy overlaps, we estimate a total 'remaining' cost-effective abatement potential in unconstrained public and commercial sector organisation of 2.6 Mt CO₂/year by 2020, of which 2.0 Mt CO₂/year would be delivered from the public sector and services, with the industry sector remains unchanged at 0.6 Mt CO₂/year.

The remaining cost-effective abatement potential is larger in the non traded sector (2.2 Mt CO₂) than in the traded sector (0.4 Mt CO₂). This largely relates to the strong influence of products policies on electricity consumption.

Policies that delivering increased renewable energy are assumed not to reduce significantly the cost-effective abatement potential from energy efficiency measures in 2020. However, interactions between renewable heat and energy demand measures are complex, and this is an area of uncertainty.

In the transport sector, we estimate that existing policies will deliver reduction in emissions from vehicles owned by SMEs of the order of 3.6 Mt CO₂/year, by 2020. The most important policies relate to alternative fuels e.g. biofuels, or improvements in the efficiency of vehicles either through regulations (for passenger cars and vans) or voluntary agreements.

4.1 Introduction

While the businesses and organisations that fall within the unconstrained sector are not subject to the major regulatory instruments of EU ETS, CRC, CCA and CERT this does not mean that their energy consumptions and CO₂ emissions are not influenced by other policy initiatives.

In the previous Chapters we estimated the current scope and scale of emissions in the unconstrained sector and the potential for abating these emissions by 2020. These estimates took into account the current energy use within the sector and the projected savings from energy efficiency measures under a business-as-usual scenario. While this business-as-usual scenario took into account the impact of certain historical policies on the uptake of abatement measures, it did not include all of the most recent policies.

This Chapter examines the impact of existing and planned policies on the emissions and abatement potential within the unconstrained sector in more detail. The results from this analysis are then used to derive an updated estimate of the cost-effective abatement potential from the unconstrained sector in 2020, once all policy overlaps have been accounted for.

4.2 Stationary sources

4.2.1 Policy impacts

There are several policies that have the potential to deliver reductions in emissions in the unconstrained sector by 2020. Understanding the impact of these policy instruments on emissions

from the sector is important both in estimating the potential level of abatement from new policies, but equally in assessing the relative influence exerted by the current policy landscape. Each of the main policies that act on emissions from non domestic buildings and industrial activities are discussed in turn below.

Building Regulations

Building Regulations specify standards of construction and design for new buildings and for certain categories of building work carried out to existing buildings. Specifically, the current regulations require minimum standards for energy efficiency for all types of new buildings, and existing buildings with useful floor areas in excess of 1,000 m² that are subject to building works. Around 65% of the carbon savings from the regulations in non-domestic buildings will arise from the refurbishment of the existing stock.

The requirements of the Building Regulations effectively provide some degree of mandation with regards to the replacement of certain technologies. These include boilers, air conditioning system and glazing. The regulation should also motivate the more economically feasible building fabric improvements as part of major refurbishments.

The estimated carbon savings from the Building Regulations, as outlined within the latest DECC energy modelling (UEP39) relate to the improvement in building performance brought about by the requirement of Part L of the 2006 Building Regulations. It also included the requirements of Articles 3 to 6 of the Energy Performance of Buildings Directive (EPBD). The proportion of these savings that are estimated to arise in the unconstrained sector are shown in Section 4.2.2 below.

Going forward, the Government has set an ambition that all new non-domestic buildings be built to a zero carbon standard from 2019³⁰. These proposals only apply to England. The current proposals allow for phased improvement in efficiency standards, beginning with 25 per cent improvement in 2010 (DCLG, 2009³¹). If taken up, these proposals would lead to additional savings over and above those outlined in UEP39.

Energy Performance of Buildings Directive

UEP39 also includes savings projected to arise from the implementation of Articles 7 to 10 of the Energy Performance of Buildings Directive. This includes measures such as Energy Performance Certificates, Display Energy Certificates for public buildings, inspections for air conditioning systems, and advice and guidance for boiler users.

Products policy

Products policy mainly targets electricity use with products ranging from tertiary lighting to motors. It aims to make these products more energy efficient and to inform consumers on the energy efficiency of the product they purchase. Products policies include measures implemented at an EU level, such as minimum product standards, but also initiatives such as voluntary agreement that might be implemented at the UK level.

Smart metering

This policy will involve a mandated roll out of smart and advanced meters to non-domestic buildings (SMEs). The intention is with better metering of energy use the occupiers of non-domestic buildings will have better information on their energy use and so will decrease their use of gas and electricity. In the policy Impact Assessment it was assumed that smart/advanced meters – coupled with the provision of data to consumers – will reduce energy consumption by 2.8% (electricity) and 4.5% (gas) per device installed, in the central case. This was based on evidence from a field trial of advanced metering of SME sites that was carried out by the Carbon Trust³².

³⁰ www.hm-treasury.gov.uk/d/bud08_chapter6.pdf

³¹ Proposals for amending Part L and Part F of the Building Regulations – Consultation

³² Advanced metering for SMEs: Carbon and cost savings', Full Report, Carbon Trust, May 2007

Carbon Trust advice and loans

The Carbon Trust, through a range of activities, work with business and the public sector to identify carbon emissions, find ways of cutting them, and provide the know-how and resources to help them do so. An important measure for the unconstrained sector is the Carbon Trust's Energy Efficiency Loans. These are designed to overcome the capital barrier of purchasing energy saving equipment. Loans are interest free, and provided on an unsecured basis. The measures eligible for support under the scheme include both building and industrial process technologies. Under the current requirement of the scheme, the loans are only available to businesses that do not qualify for participation in the CRC. Therefore, all of the savings from this initiative arise in the unconstrained sector.

Public sector loans

Loans are available to public sector organisations to fund investments in energy efficiency measures. The scheme is administered by the Carbon Trust, and runs on a revolving fund basis where the revenues from the energy savings are recycled to fund additional measures.

Renewable Heat Incentive (RHI)

The RHI is a planned financial incentive to install renewable measures to supply heating to buildings. Its objective is to increase the renewable heat demand to 13% (12% in addition to the business as usual) of total heat demand by 2020. It will apply to generation of renewable heat at all scales, whether it is in households, communities or at industrial scale. The RHI will be banded for example by size or technology (e.g. larger scale biomass heat may require less support per MWh than others).

The RHI will effectively deliver renewable heat technologies. Some of these will be installed by organisations within the unconstrained sector. The measures will be installed in both existing buildings, for example instead of a replacement conventional boiler, but also within new developments.

Feed-in Tariff (FiT) scheme

FiTs are an incentive for the installation of renewable measures with a capacity below 5 MW. The FiT scheme is expected to bring about around 770,000 renewable energy installations (and 30,000 domestic micro CHP installations) in addition to the number otherwise achievable under the business-as-usual scenario in 2020³³. The majority of renewable devices are projected to be installed within the domestic sector, although there are some installations anticipated in the non-domestic sector.

Other measures

In addition to the policies highlighted above, there are a number of other initiatives that will provide support to businesses within the unconstrained sector in delivering reductions in emissions. These include, among others, a number of resource efficiency programmes delivered by Regional Agencies, and the Government's voluntary Business Energy Efficiency Agreements (BEEAs) with energy suppliers. These initiatives have not been included in the LCTP as separate policies. On this basis, we have assumed that the impacts of these initiatives either form part of the savings allocated to other policies, or deliver savings that are overall small – so have not been quantified. These policies have not been further considered here.

4.2.2 Allocation of savings to the unconstrained sector

For each of the main existing and planned policies, an estimate has been made of the impact of these policies on the take-up of abatement measures in the unconstrained sector, and the associated savings. This approach has been applied top-down i.e. to take the original estimates of the carbon savings from the policies in UEP39 and then disaggregate the proportion of these savings that are expected to be delivered in the unconstrained sector. Where possible, these results have been cross-checked with the bottom-up assumptions that have been made for the penetration of individual abatement measures in the MACC analysis. However, the two approaches cannot be considered fully consistent.

³³ FiTs Impact Assessment accompanying Government Response

In most cases, the savings have been scaled in accordance with the estimated energy use that is covered by the unconstrained sector, allowing for differences in the policy coverage by sub-sectors. This assumes that the policies will apply equally to all organisations within the given sector. For certain policies this may lead to an over or under estimate of the actual savings in the unconstrained sector. For example, the Carbon Trust's interest free loans are only open to organisations below the CRC threshold. However, on the whole this approach is considered to represent a reasonable approximation of the impacts in the sector, while also providing a consistent approach for each of the policies.

The scaling factors that have been applied for each of the policies is summarised in the table below. Some commentary has been added on the potential limitations of the approach, where relevant.

Following this scaling, two further adjustments were made to the policy estimates so that they could be compared on an equal basis with the results from the MACC modelling in the previous Chapter:

1. For the commercial and public sector, the policy savings have been adjusted to reflect the fact that not all of the savings will apply to existing buildings, but some will also act upon new buildings. Since the abatement potential estimated previously using N-DEEM only related to the existing building stock then this adjustment is required before making a comparison. In most cases, data on the split of savings are not reported so a judgement has been made on the distribution of savings. The exception is the Building Regulations where an estimate of the split is presented in the policy Impact Assessment.
2. It is necessary to relate the savings from the policies to the abatement measures in the MACC model. In most cases it has not been possible to do this at the individual measures level, so a more simplified approach has been applied. An estimate has been made of the proportion of the policy savings that are associated with cost-effective measures, and the proportion related to measures that are not cost-effective. While this does not say how much of the abatement potential is taken up for each of the measures, it does estimate the impact of existing policies on the overall cost-effective potential for the sector as a whole³⁴. For products policy, smart metering and the EPBD we have assumed that almost all of the measures installed will be cost-effective. For the building regulations and policies delivering alternative energy sources we have assumed that up to 25% of the savings may relate to abatement measures that are not considered to be cost-effective in the current N-DEEM analysis. In other words these latter policies will take up some of the cost-effective abatement potential, but will also take up some of the technical potential from measures that are not cost-effective (within N-DEEM).

³⁴ This is a second best approach, and should not be considered as accurate as an approach that examines each of the individual abatement measures separately. However, since this level of detailed analysis was not possible, the current approach provides a more refined estimated than simply assuming that all of the savings will relate to cost-effective measures.

Table 4-1: Scaling factors for allocating LCTP policy impacts to the unconstrained sector

Policies	Scaling factor	Comments
Building regulations	% of each sector's total energy use that falls within the unconstrained sector	This does not allow for the fact that requirements for existing buildings only apply to sites with a floor area greater than 1,000 m ² threshold. On the basis that organisations within the unconstrained sector will typically operate from smaller sites, this will over-estimate the policy impact in the unconstrained sector
Energy Performance of Buildings Directive	% of each sector's total energy use that falls within the unconstrained sector	Measures will not act equally across the sector, with measures such as Display Energy Certificates biased towards public sector. However, this is, to some extent, addressed by allocating emissions on a sub-sector basis, i.e. by considering the savings in the public sector separately.
Carbon Trust	% of each sector's total energy use that falls within the unconstrained sector	This will underestimate the savings from certain activities, specifically the interest free loans which are aimed at organisations below the CRC threshold. However, savings from other Carbon Trust services are likely to be overestimated, as these are targeted on larger energy users.
Products policy	% of each sector's electricity use that falls within the unconstrained sector	While the majority of savings from products policy relate to electricity consumption some of the savings may also relate to other fuels.
Renewable Heat Incentive	Bottom-up estimate based on modelling carried out by AEA of the RHI.	This takes into account the estimated heat demand from sites that fall below the CRC threshold, based upon a bottom-up methodology. A correction factor has been applied to allow for the fact that the bottom-up estimate will not factor in sites that will come under CRC through the parent organisation.
Smart meters (SME)	% of each sector's electricity use that falls within the unconstrained sector	While this policy aims to target smaller energy users, this does not necessary mean that the parent organisation will be outside the scope of CRC. For example, the smart meter may be installed in organisations that also have half-hourly meters and meet the eligibility requirements for CRC. On this basis savings in the unconstrained sector have been allocated pro-rata in relation to the electricity consumption from the unconstrained commercial sector.
Feed-in Tariff	Estimated by DECC	It was assumed that SMEs would be more likely to take on technologies from the smaller end of the spectrum and that the majority of energy would be produced on-site.
Loans to public sector	% of public sector energy use that falls within the unconstrained sector	While the take-up of loans will vary across different elements of the public sector, this is considered to provide a reasonable approximation of the net impacts.

4.2.3 Results

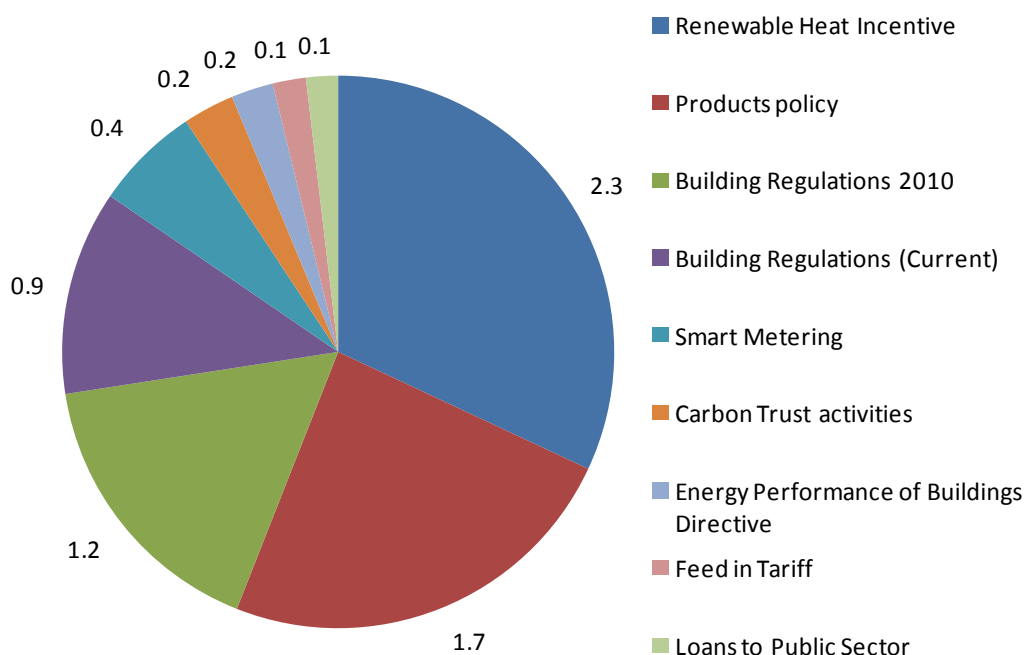
On the basis of the scaling factors described above, existing policies are expected to deliver in the order of 7.2 Mt CO₂ of annual savings from buildings and industrial activities in the unconstrained sector by 2020. While these estimates should be considered indicative, the estimates do suggest that current policies will make an important contribution to the reduction in energy use and CO₂ emissions from the sector in the first carbon budget period.

The policy that is expected to have the most significant impact is the RHI. The next most important policies are regulatory in nature – Building Regulations and Products policy³⁵. Smart metering also appears to be an important policy for the sector.

The impact of supporting measures, such as the Carbon Trust activities, are generally smaller in aggregate terms, although on an individual basis these policies can be important for overcoming key barriers to the take-up of energy efficiency measures in the sector. For example, the interest free loans offered by the Carbon Trust are important in overcoming issues around access to capital.

The chart below estimates the annual emissions savings in 2020 that are projected to be delivered in the unconstrained sector from each of the individual policies. This includes impacts on both the existing stock of buildings, but also savings associated with improved energy efficiency in new buildings.

Figure 4-1: Estimated annual savings from existing and planned policies in the unconstrained sector in 2020 (Mt CO₂)



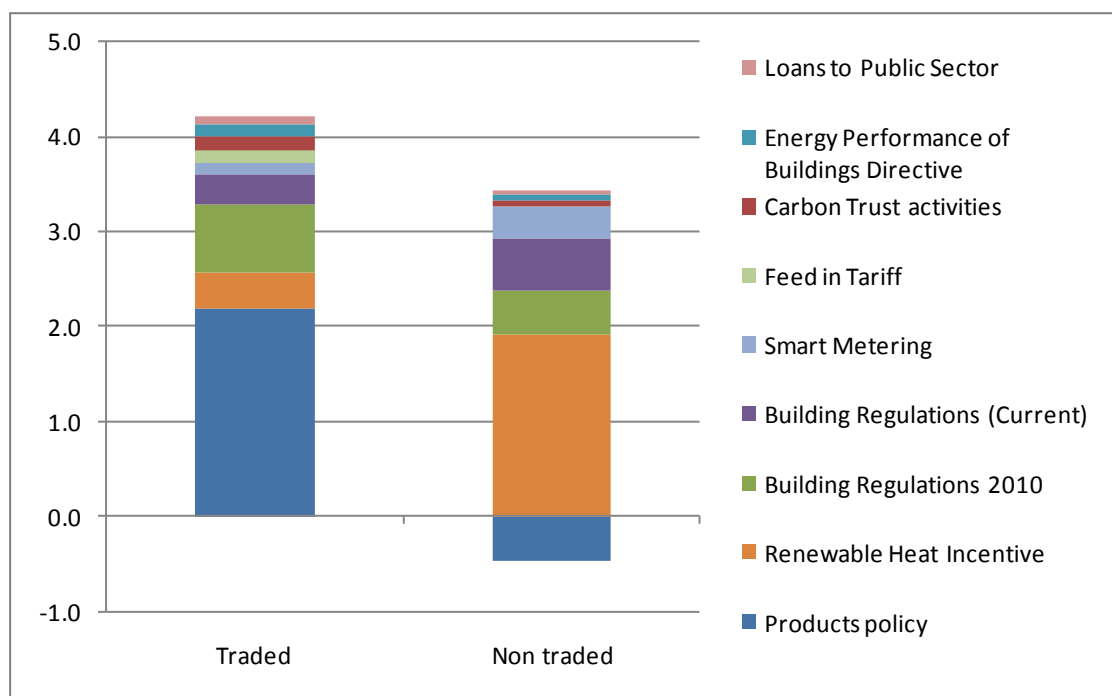
Notes: Building Regulations (2010) estimated from Implementation Stage Impact Assessment of Revisions to Parts F and L of the Building Regulations from 2010.

To help understand the relative contribution of the policies to the UK Carbon Budget, a distinction has been made between those savings that will arise in the traded sector, and those in the non-traded sector. Certain policies have a much greater influence on traded emissions (e.g. products policy). However, for others the impact on non-traded emissions is greater (e.g. RHI).

³⁵ Products policy includes certain non-regulatory policies, although the majority of savings arise from regulatory mechanisms, such as the minimum standards introduced as part of the Energy Using Products Directive.

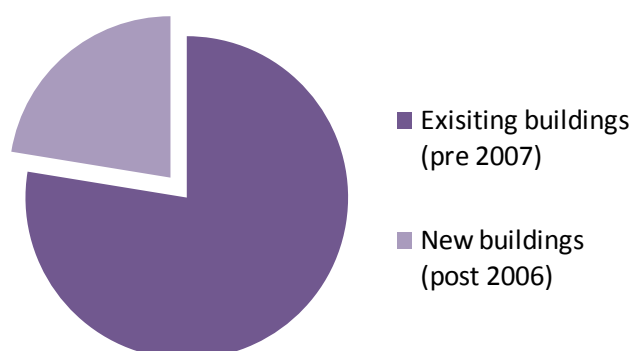
The split of savings by traded and non traded emissions is shown in the figure below. The 'negative savings' from products policy in the non-traded sector is a result of the heat replacement effect.

Figure 4-2: Estimated annual savings from existing and planned policies in the unconstrained sector in 2020 (Mt CO₂), split by traded and non traded sectors



An estimate has also been made of the proportion of the savings that relate to existing buildings and the proportion related to new buildings. Overall, we estimate very crudely that around 78% of the savings will relate to buildings constructed before 2007. This estimate has been made by approximating the proportion of the savings from each of the policies that might be related to new buildings. In most cases this was an expert judgement.

Figure 4-3: Estimated policy savings relating to existing and new buildings



Remaining cost-effective potential once policy overlaps have been accounted for

A proportion of the savings identified above will arise from the take-up of technical abatement measures described in Chapter 3. Therefore, to ensure that the overall cost-effective abatement potential from the sector is not over-estimated, it is necessary to account for these overlaps.

In the analysis presented in Chapter 3, the business-as-usual uptake of abatement measures included the impacts of the 2006 Building Regulations, the Carbon Trust programmes and public sector loans. In other words the impact of these policies was already factored into the modelling. This equates to about 1.2 Mt CO₂ of annual savings in 2020.

Of the remaining 6.0 Mt CO₂ of annual policy savings identified above 2.4 Mt CO₂ can be attributed to savings from renewable energy (for example from the RHI) and 3.6 Mt CO₂ to energy efficiency measures. However, not all of these savings will apply to the existing building stock as described in Chapter 2.

For those policies that deliver increased uptake of energy efficiency measures, we have assumed that all of these savings will relate to the take-up of technical abatement measures identified in the previous Chapter. Therefore, once adjustments are made for the proportion of these savings that apply to existing buildings, and the split of savings between cost-effective and not cost-effective measures, these savings can be netted off from the cost-effective potential estimated previously.

For the policy savings that relate to renewable energy the situation is more complex. Renewable energy technologies were not included in the MACC model, but will interact with the technical abatement from energy efficiency measures. This interaction will occur in two ways.

- Firstly, the estimated savings from renewable energy measure will directly overlap with certain measures in the current model. This specifically relates to the measures that deliver a more efficient energy supply, specifically the measure 'more efficient boiler'. However, since the majority of the savings from this measure are assumed to arise in the business-as-usual scenario³⁶ the impact of this interaction on the remaining energy efficiency measures in 2020 is minimal. We therefore assume limited direct overlap between the savings from the RHI and the remaining cost-effective potential in 2020.
- Secondly, the renewable heat measure will interact with the other heat-related abatement measures, by reducing the apparent carbon savings from subsequent measures. This interaction is difficult to correct for with any certainty and will depend upon the level of energy efficiency assumed in the heat modelling, and the level of renewable heat assumed in the energy efficiency modelling. For simplicity, we have assumed that this interaction has been allowed for in the underlying modelling. In practice, this may not account for the interaction sufficiently – particularly for the carbon savings from the energy efficiency measures where the underlying modelling did not allow for a level of renewable heat comparable with the levels that may be delivered by the RHI.

Therefore, in the current analysis, we assumed that policies that deliver renewable energy supplies (RHI and the FiTs) will not exhaust any of the remaining carbon abatement potential in 2020. However, they will overlap with some of the assumed business-as-usual take-up of abatement measures and will deliver additional carbon savings where the technologies are more efficient in delivering energy supplies than the counterfactual technology.

In summary, for the public and commercial sectors we estimate that the energy efficiency policies outlined above, that are additional to the business-as-usual scenario, will take up about 2.6 Mt CO₂ of the cost-effective abatement potential identified in Chapter 2 (and a further 1.0 Mt CO₂ from not cost-effective measures, and measures in new buildings). For the industry sector we assume the overlaps are minimal, since the bulk of the measures targeting this sector are in the 'constrained' proportion. These results are shown in the table below.

Table 4-2: Remaining cost-effective potential in 2020 once policy overlap have been accounted for

	Total CE abatement potential	Electricity savings	Non electricity savings
	Mt CO ₂	Mt CO ₂	Mt CO ₂
Public and commercial	2.0	0.1	1.9
Industry	0.6	0.3	0.3
Remaining potential	2.6	0.4	2.2

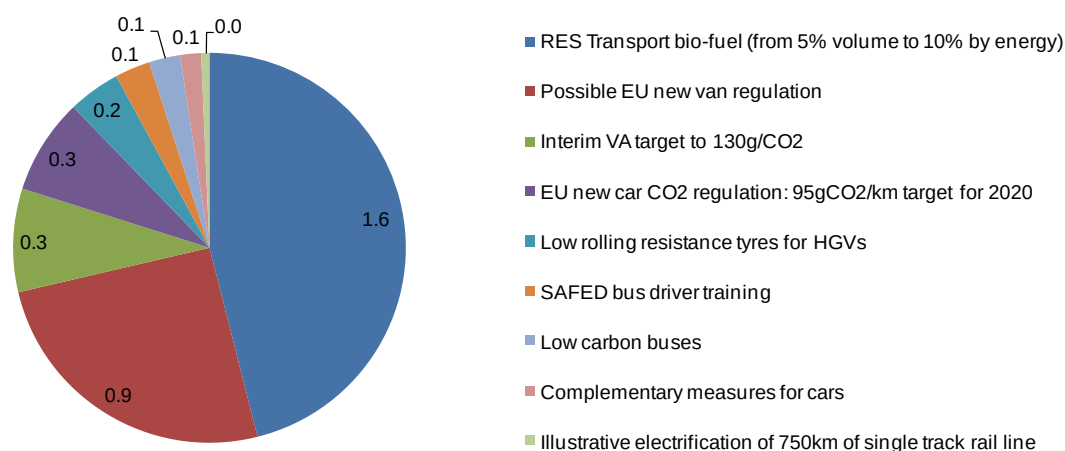
³⁶ The business-as-usual scenario assumes that almost all conventional boilers will be replaced by more efficient boilers by 2020. However, with the RHI, a proportion of the heating systems will be replaced with renewable heat (on the basis of the assumptions within the RHI impact assessment).

4.2.4 Transport

A number of policies were outlined in the LCTP that apply to the transport sector. Emissions savings are not specifically estimated for the unconstrained sector, in most cases. It is therefore necessary to carry out some further analysis of the relative proportion of the emissions savings that are likely to fall within this sub-sector.

The overall savings from each policy have been reduced by a factor which represents the SME-related emissions from the mode to which the policy relates. The estimate has been calculated on the basis of the direct emissions i.e. impacts on SME-owned vehicles only. This is likely to represent an underestimate of the total impacts as it will not include all of the indirect emissions. The results are shown in the figure below.

Figure 4-4: Impact of current policies on SME transport CO₂



Overall, we estimate that these existing policies will deliver emissions savings from vehicles owned by SMEs of about 3.6 Mt CO₂/year, by 2020. The most important policy is the Renewable Energy Strategy (RES) biofuel target which is projected to deliver almost half of the savings. The next batch of policies relate to improvements in the efficiency of vehicles either through regulations (for passenger cars and vans) or voluntary agreements. The other policies, including behavioural measures such as SAFED bus driver training are small in comparison, but important for individual modes.

Of the policies described above, almost all of the projected emissions reductions can be considered additional to the business-as-usual scenario used in the MACC analysis in Chapter 2. In other words, the above policies would be expected to deliver a proportion of the abatement potential that was identified in Chapter 2. More specifically:

- The estimated abatement from the policy on low rolling resistance tyres for HGVs closely matches the technical abatement from this measure in the MACC, suggesting a high level of penetration of this measure by 2020.
- The savings identified from the possible EU van regulations is close to the estimated abatement potential from all measures aimed at light duty vehicles. This suggests either the MACC underestimates the abatement potential for this mode or the regulations are expected to be set at a very stringent level.
- The savings from measures aimed at passenger cars deliver less than half of the technical abatement potential.

For the most important policy, the RES 10% biofuels target the situation is slightly different. The business-as-usual scenario used in the MACC analysis actually assumed the uptake of biofuels in line with the requirements of the Renewable Energy Strategy. Therefore, the savings from this policy are already accounted for in the MACC business-as-usual scenario, so any uptake of biofuels beyond this target will deliver additional savings.

Assuming that all of the policies described above will deliver in line with the latest estimates, and taking into account the overlaps with abatement potential identified in Chapter 2, we estimate a remaining abatement potential from the application of technical measures to SME-owned vehicles of around 2.8 Mt CO₂ of annual emissions in 2020. None of this potential is currently cost-effective, from a social perspective.

5 Barriers and drivers

Chapter summary

- Previous research has shown that even if there is a strong economic case for taking up energy efficiency measures, other barriers exist which may mean that abatement measures are taken up a slower rate than predicted by economic models.
- To understand these barriers in more detail, and the potential options for mitigation, some new market research has been carried out. This has provided an improved understanding of the available measures to overcome barriers to the uptake of energy and fuel efficiency measures within 'unconstrained' businesses.
- 400 interviews were conducted with businesses in England that lie within the 'unconstrained' sector. All non-domestic sites were prompted as to the level of action that had been taken in lighting, heating and insulation. All sites that operated vehicles were prompted as to the level of action that had been taken in fuel efficiency.
- Across all business sectors and sizes, cost savings were found to be the principal motivation for action and a factor in the decisions of most sites to take action to implement energy saving measures. Reducing environmental impact was also found to be important for some businesses, while for insulation activity increased comfort was a powerful motivator for action. Reducing environmental impact was found to be a much more important motivator for action at industrial sites than at commercial sites.
- Across all measure types, the cost of action and uncertainty as to what could be done were principal barriers. Other commonly cited barriers included doubts over return on investment and (for energy measures) the difficulty of taking action in rented premises.
- Only 20% of businesses had accessed external advice on energy or fuel efficiency. Large sites, industrial sites, and those with larger energy bills were significantly more likely to have accessed support. Of those that had accessed external support, the main sources were Carbon Trust services and the internet (33%). 54% of those receiving advice said they had acted upon it; sites were most likely to have acted where they received advice through a site audit.
- This suggests that more can be done to help small business to start the journey to understand and drive down their energy consumption and CO₂ emissions. There is potential scope to improve the level of action taken through:
 - Financial/fiscal stimulus.
 - Site audits.
 - Landlord incentives.

5.1 Introduction

In the previous Chapters, we have estimated that there is significant potential for organisations within the unconstrained sector to reduce their emissions while also delivering financial savings from the reduced energy costs. However, even if the economic case for taking up abatement measures is strong, other barriers exist which may mean that abatement measures are taken up a slower rate than predicted by economic models.

To understand these barriers in more detail, and the potential options for mitigation, some new market research has been carried out. Led by Databuild, and building upon the research already conducted by DECC and other bodies, the research has sought to provide improved understanding of the available measures to overcome barriers to the uptake of energy and fuel efficiency measures within 'unconstrained' businesses.

5.2 Background

A number of previous studies have investigated SME behaviour and attitudes towards energy efficiency and climate change issues.

The previous research has highlighted a number of motivations and barriers for businesses to take action to reduce energy consumption. Motivations have generally included reduction in costs, reducing environmental impact and improved customer image, while barriers have generally included the cost of action, lack of knowledge/awareness, lack of spare time to address these, and tenant limitations.

Some of the studies have also suggested policy changes that may be used to stimulate action e.g. greater Government-funded support to SMEs, improved promotion of existing support, and taxes to incentivise activity.

While there is therefore a large amount of qualitative and theoretical research listing drivers, barriers and potential solutions, there is a need for further evidence to support policy decisions in the unconstrained sector. Specifically, there is a need for further research on:

- Quantitative ranking of barriers.
- Separation of principal barriers from peripheral barriers.
- More articulation and critique of the barriers cited by businesses i.e. is money actually a barrier? What would businesses do with it if they had it?
- Greater understanding of how the barriers relate to the sectors and companies that make up the unconstrained sector.
- Greater consideration of non-policy drivers of energy efficiency within SMEs.
- More detailed consideration of how the issue of landlord – tenant barriers can be overcome.

The market research that has been carried out in this study was specifically designed to extend and enhance the existing evidence base by addressing these research areas. This information can then be used to inform how best to mitigate the barriers within different segments, and how to prioritise Government intervention to maximise the effectiveness of interventions in this area.

5.3 Methodology

400 interviews were conducted with businesses in England that lie within the ‘unconstrained’ sector. The sample was structured on the basis of size, with a random split in sector and property tenure. The size bands were constructed on the basis of site employee numbers, as follows:

- 0-1 employees (sole traders) – 80 interviews.
- 2-9 employees – 120 interviews.
- 10-49 employees – 130 interviews.
- 50+ employees – 70 interviews³⁷.

Although no quota was placed on different sectors, the sector types were split into the following groups on the basis of their SIC code:

- Agriculture and primary.
- Manufacturing.
- Construction.
- Wholesale and retail.
- Hotels and catering.
- Transport and communications.

³⁷ Although the majority of interviews with sites in this size group were conducted with SMEs i.e. those with fewer than 250 employees, a small sample of large/non-SME businesses were sampled, since some businesses in the unconstrained sector may be larger than SMEs.

- Business services.
- Personal services.

For smaller sites, the key decision maker within the organisation (i.e. owner/managing director) was interviewed. For larger sites the person with overall responsibility for energy efficiency on site (usually either a director or specialist manager) was interviewed.

Domestically based businesses (i.e. businesses operating from someone's home) were only interviewed where vehicles are operated as part of their business.

5.3.1 Weighting the data

The survey population was segmented into the employees size bands described above, and the survey results were weighted according to the to site numbers in England within each size band.

The weighting was carried out in accordance with the following steps:

1. BIS stats³⁸ were used to identify the total number of businesses in England within each size band.
2. The responses to the survey question 'How many sites does your organisation operate from?' were used to derive an average number of sites per organisations, within each of the size bands. For example, businesses in the 2-9 employee size band, had, on average, 1.1 sites per business.
3. The organisations were then given a site weighting factor by multiplying the number of organisations in the site size band (identified through the BIS stats) by the average number of sites in that size band e.g. there are 720,312 organisations with 2-9 employees in England, so the site weighting factor for these respondents was obtained by multiplying 720,312 by 1.1.

50+ employee sites were weighted to all business sizes over 50 i.e. not cut off at 249 employees. This is because a small sample of +250 employee sites were deliberately included in the sample, as not all will be covered by CCAs or the CRC.

5.4 Key findings

5.4.1 Non-constrained sector profile

Site ownership

83% of sites interviewed were commercial premises; the remaining 17% were domestic premises that operate vehicles as part of their business. In the SME population as a whole, 57% of sites were business premises and 43% are in domestic premises. Those organisations operating from domestic premises were not asked about their energy efficiency activity as domestic energy use is outside the scope of our analysis; these emissions are already covered through mechanisms such as CERT.

Business premises became increasingly common the larger the site's number of employees; there were almost no domestically based sites in businesses with more than 10 employees. Manufacturing/industrial sites were those most likely to be business based.

Where sites operated from a business premises, respondents were asked about the way in which the premises were owned/paid for. This gives an indication of the extent of the barrier associated with the landlord-tenant split³⁹. 60% of premises are rented from commercial landlords while 30% are owned by the business and 9% are owned by the business owners/directors. The remainder of sites are either rented from adjacent businesses or are part-owned, part-rented.

³⁸ <http://stats.berr.gov.uk/ed/sme/>

³⁹ This problem occurs, for example, when the landlord provides energy-using appliances (such as a refrigerator or lighting systems), but the tenant pays the electricity bill. In this situation, there is little incentive for the landlord to choose the most energy-efficient appliance

Industrial (i.e. manufacturing/primary) sites (67% owned) were significantly more likely to be owned by the business than commercial (all other site types) sites (36% owned).

Businesses in the agriculture, manufacturing and hotel/catering sectors were those most likely to own the site premises. Construction and wholesale and retail businesses were most likely to be renting premises.

Businesses with more than 50 employees were slightly more likely to own premises. Single employee sites were as likely to be owned by the business as sites with between 2 and 49 employees.

Bills

43% of sites pay both electricity and gas direct to the supplier, a further 43% pay only electricity to the supplier, less than 1% pay only gas, while 14% do not pay utility bills directly to the supplier. This means that for many businesses, energy is under their control and they get the benefit of savings as they own the premises and/or pay utility bills.

92% of industrial sites pay bills direct to the supplier compared to 86% of commercial sites.

Where sites did not pay for their electricity or gas directly, 39% pay for it through their premises rent while 36% pay through a separate service charge. The remainder included various responses; most did not know how site utility bills were paid as they were met by a parent company or head office, or resolved by a broker. A very small proportion of sites do not have utility bills due to the nature of the site.

On less than 1% of owned sites, the business does not pay for the bills. In contrast, bills are not paid by the business on about one fifth of rented sites.

Where bills are paid by the business, 65% pay less than £1,000/year, 26% pay between £1,000 and £4,999, and 10% pay £5,000 or more.

8% of industrial sites pay annual energy bills of more than £5,000 compared to 1% of commercial sites. 93% of commercial sites pay less than £1,000/year compared with 80% of industrial sites.

Vehicle use

72% of businesses operate vehicles. The business pays for the fuel for these vehicles in 96% of cases.

External advice accessed

All respondents were asked whether they had ever previously sought advice on reducing energy/fuel use. Only 20% said they had done so.

There were differences between different types of business in terms of likelihood of having accessed advice:

- 24% of industrial sites have previously sought advice compared to 19% of commercial sites.
- Large sites and organisations were significantly more likely to have sought and received advice. 68% of sites with more than 50 employees had sought advice, compared to 37% of sites with 10-49 employees and 14% of sites with fewer than 10 employees.
- 82% of those paying more than £5,000/year on energy bills had sought advice compared to 17% of those paying less than £1,000/year.
- Owned sites were also slightly more likely to have sought advice. 29% had done so compared to 23% of rented sites.

Of those that had accessed external support, the main sources were Carbon Trust services (cited by 36%), 'the internet' (no particular website specified) (33%), energy suppliers (18%), and specialist energy consultancies (17%). Research on behalf of businesslink.gov.uk shows that where businesses use the internet, this is usually typing a particular issue or information need into a search engine rather than specifying a particular website.

Overall, only 67% of respondents were satisfied with the advice they received while 23% were dissatisfied. Where advice was very satisfactory, the advisors were found to be helpful, focused upon the business, friendly and practical. They also clearly demonstrated cost savings. Conversely, where advice was unsatisfactory, it was seen as being impractical to implement, costly and generic.

Those accessing workshops or seminars were the most likely to be satisfied with the advice received. 91% were satisfied compared to 84% of those using on-line resources, 74% of those receiving a site audit, and 57% of those receiving telephone advice.

54% of those receiving advice said they had acted upon it; sites were most likely to have acted where they received advice through a site audit.

The larger the number of employees, the more likely the site was to be satisfied with the advice received, and more likely to act upon it. Not surprisingly, there was also a correlation between satisfaction with the advice and propensity to take action.

5.4.2 Levels of action

Businesses based in domestic premises were not asked about energy efficiency activities as the 'site', if considered to be a domestic property, is already covered by mechanisms such as CERT and is therefore not considered to be part of the unconstrained sector.

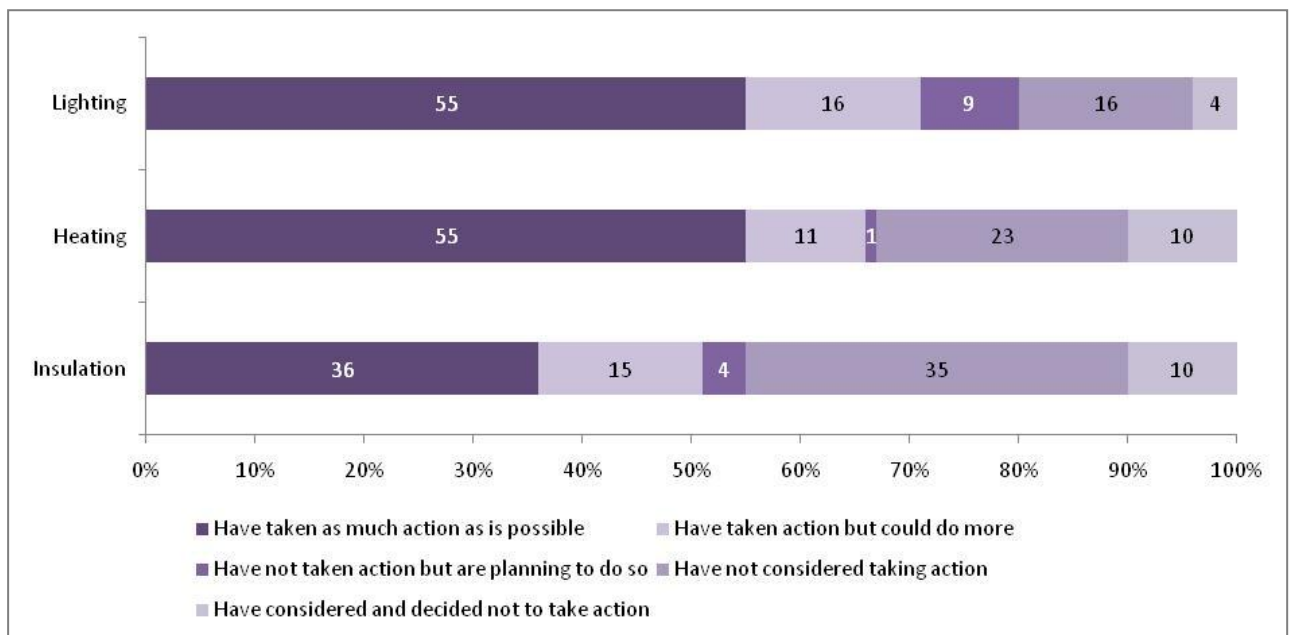
Energy activity

All non-domestic sites were prompted as to the level of action that had been taken in:

- Lighting e.g. energy efficient bulbs, timers.
- Heating e.g. boiler replacement, heating controls.
- Insulation e.g. loft and/or wall insulation.

The extent of action in each area is shown below:

Figure 5-1: Extent of energy action (n=333, N=2,644,815)



24% of commercial sites felt that they had done everything possible for all three measures, compared to just 5% of industrial sites.

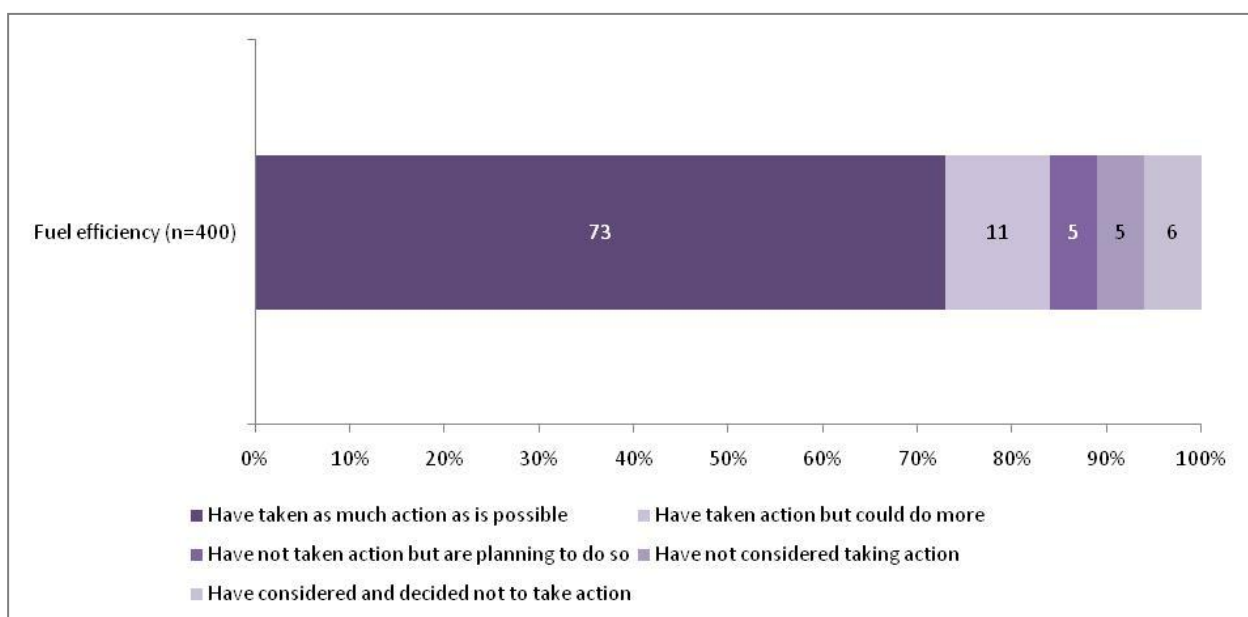
The greatest potential for activity is in insulation – 49% of sites have yet to take any action in this area, compared to 29% for lighting and 34% for heating.

Sites which do not pay their own bills and sites paying less than £1,000/year on energy were the most likely not to have investigated actions they could take.

Fuel efficiency

All sites that operated vehicles were prompted as to the level of action that had been taken in fuel efficiency e.g. driving techniques, aerodynamics, cleaner fuels, cleaner vehicles?:

Figure 5-2: Extent of fuel efficiency action (n=400, N=2,999,160)



5.4.3 Summary of barriers

All sites were asked (both unprompted and with prompting) as to what the principal barriers to taking further action in each area were. The following table shows the five most commonly selected barriers and five most commonly selected principal barriers by measure type. The % of respondents selecting a barrier for each measure is shown in brackets:

Figure 5-3: Table of most common barriers by measure type

LIGHTING		HEATING		INSULATION		FUEL EFFICIENCY	
Barrier	Principal barrier	Barrier	Principal barrier	Barrier	Principal barrier	Barrier	Principal barrier
Money (51)	Money (25)	Money (36)	Money (16)	Money (41)	Rented premises (21)	Money (30)	Money (15)
Unsure what to do (49)	Unsure what to do (20)	Unsure what to do (28)	Unsure what to do (12)	Rented premises (34)	Unsure what to do (14)	Return on Investment (26)	Unsure what to do (14)
Return on Investment (39)	Rented premises (15)	Return on Investment (25)	Rented premises (11)	Return on Investment (31)	Money (13)	Unsure what to do (25)	Return on Investment (8)
Time (36)	Time (9)	Rented premises (24)	Unsure how to implement (5)	Time (26)	Time (9)	Disruption (13)	Time (7)
Rented premises (33)	Return on Investment (6)	Unsure how to implement (23)	Return on Investment (4)	Disruption (25)	Return on Investment (8)	Unsure how to implement (11)	Disruption (5)

The table excludes 'no barrier' responses i.e. the respondent could not think of any barriers to take action. This accounted for at least a quarter of respondents on any measure.

A significant proportion of respondents said that they did not have any barriers to taking action in areas, there was simply nothing more they could do. This seems unlikely. In the case of many sites, 'there is nothing more I can do', should really be taken to mean 'there is nothing more I can do that seems to be sensible/cost-effective'.

This is a perception that can be challenged through site reviews/tailored support (described below).

5.4.4 Opportunities to promote action

Money

The table shows that money (either capital cost or return on investment) is the predominant barrier across all measure types.

Although industrial sites were less likely than commercial sites to select cost savings as a motivation to action, 58% cited it as their principal barrier to action compared to 49% of commercial sites. Sites with >£5,000 energy bills were significantly more likely to cite money savings as a motivation than those with <£1,000 annual bills.

However, respondents citing disruption as a principal barrier claimed that a variety of measures would create discomfort, create loss of revenue through buildings being closed/only partly usable, and possibly lead to permanent loss of customers. Respondents envisaged that certain measures could mean noise, power cuts (or the need to keep power switched off), raised flooring, and reduced working spaces.

Regarding fuel efficiency measures, respondents argued that introduction of certain techniques or fleet renewal could disrupt operations and reduce customer service.

Therefore, as disruption is also tied to financial concerns, provision of support to address the funding barrier may help to overcome obstacles in even more sites than those that explicitly cited capital cost.

This report supports the suggestions of previous research that there is scope to better promote existing mechanisms (ECAs) and use fiscal policy as an incentive to action.

In addition to these, other mechanisms that could be effective are:

- PAYS: although no businesses mentioned the Pay As You Save concept, this would reduce risk and provide up-front capital.
- Warm Zones: could be extended to industrial estates, retail parks or offices.
- ESCOs: Energy Service Companies could assist in advice provision and measure identification as well as identifying and delivering finance packages.

Uncertainty as to what can be done

Almost as widespread a barrier as cost (across all measure types) was knowledge of what could be done.

31% of commercial sites cited this as their principal barrier compared with 19% of industrial sites.

Those that stated they had taken as much action as possible and those that had not investigated it were the most likely to mention this as a barrier without prompting. This implies that there are two groups facing this barrier; one that are starting from a position of complete ignorance on energy/fuel efficiency measures, and those that have taken some action already and do not know where to go from there.

The challenge is therefore to overcome the perception that there is nothing more to do.

Site visits appear to be effective in encouraging action and could be effective in giving ideas on what could be done and resolving implementation difficulties (i.e. *how* to implement measures), as uncertainty in these areas is substantial. This would require a continuation of existing policy instruments (e.g. funding for Carbon Trust site audits). This extension/continuation of intensive support to SMEs has been suggested in previous sector research.

However, site audits are an expensive approach and it would not be feasible for all sites to receive them. A cheaper and potentially equally effective approach could be provision of on-line self-assessments/toolkits, whereby businesses could enter site information and receive information on appropriate measures and likely savings. However, it may be beyond the technical knowledge of most businesses to provide the sufficient level of data required to make this effective.

The fact that many of those citing time as a principal barrier said they needed the time to investigate ideas (and their potential effectiveness) means that site review support could, like funding, assist well over 2 million sites to take energy/fuel efficiency action.

Site audits could also be used to demonstrate savings to sites to overcome concerns about return on investment.

Rented premises

Industrial premises were less likely than commercial premises to cite this as a barrier because they are significantly less likely to be based on rented sites.

Where respondents stated that being in rented premises was the principal barrier to action, this was sometimes because they felt that the landlord would not approve changes.

Some respondents in rented premises also argued that they were unwilling to invest because:

- They felt it was the landlord's prerogative/duty to invest in improvements.
- They would not invest themselves because they may leave the property and not recover their investment.

Landlords tend to be the point of leverage when encouraging activity in rented premises, though tenants can be duplicitous in citing landlord prohibition when the tenant has neither asked nor indicated interest in this area.

If businesses don't pay the energy bills, they may not need to be engaged at all and efforts should be targeted at landlords; they would save bill money and could maintain the same level of rent.

Where tenants do pay the energy bill, the landlord will need to recognise some benefit themselves of investment in energy efficiency measures. This may include, for example, the ability to charge increased levels of rent. Tenants may need convincing of the need to pay the landlord more (goes back to the need to demonstrate savings clearly). Longer tenures are more likely to create tenant willingness to invest in action if landlords allow.

An incentivisation scheme for landlords could also be effective. For example, commercial energy performance certificates could be invested with more importance through corporation tax/council tax rates being based on the certificate's rating.

5.5 Conclusions

5.5.1 Profile

There are different groups of sites and different ways of examining the unconstrained population and their differing support needs. Some are positive and keen to take action, others see only barriers. Some are approaching energy efficiency action from a position of knowledge and recognising their limitations, some erroneously believe they are doing everything possible. Some sites have a large amount of control over and interest in their site (i.e. they own it and pay the utility bills), others do not.

Larger organisations and those in owned premises are more likely to have taken action and to feel that there is more they could do. Smaller sites and those in rented premises generally do not feel they have as much room for manoeuvre, usually due to lack of resources but also due to tenant limitations.

Small sites are the most polarised group; there are those that will act with no prospect of a swift return on investment because they are not financially motivated; some others are less sophisticated on energy/fuel efficiency or are not interested in it at all. There are opportunities to help these sites; however, though they are a large group (in terms of number of sites), their CO₂ impact (and potential to save) may be fairly low.

5.5.2 Motivations to action

As suggested by previous research, it is clear that across all business sectors and sizes, cost savings are the principal motivation to action and a factor in the decisions of most sites to take action. Reducing environmental impact is also important to some businesses, while for insulation activity comfort can also a powerful motivator to action on specific measures, but money is generally most important.

This indicates the importance of providing compelling data to show which measures will help sites to save money, how much and how quickly. Although a small proportion of sites may take action for more altruistic reasons (and messages such as increased comfort or customer image should be promoted), the clearest message to business needs to be the savings available.

Industrial sites were significantly less likely than commercial sites to cite cost savings as a principal motivation across all measures; reducing environmental impact was generally more important and potentially tied in with company policies or compliance/targets. Commercial sites may be less likely to

see an obvious need to reduce their environmental impact and tend therefore to identify and justify action only where it produces financial benefit.

5.5.3 Barriers to action

Lack of funding and lack of knowledge as to what can be done (coupled with a perception that everything sensible has been done already) have arisen as theoretical barriers in many previous research reports. This research has shown them to be the two principal barriers for sites.

Businesses ultimately wish to remove financial risk and hassle from the process of taking energy efficiency action. This means providing advice on what can be done, reassurance on feasibility, and finance packages to help them to identify, plan, implement and fund action.

This report aimed to test the extent to which funding (oft cited) was really the key barrier to action. Although the request for funding can be a knee-jerk response from a small number of businesses, lack of capital to invest and fears of financial risk do seem to be a key barrier to action for the majority of businesses. Most businesses requesting funding do seem to have thought about what they would spend the money on. Financial packages could be effective to help pioneering sites take high-saving action which is not financially viable.

Many other barriers - e.g. lack of time and disruption - also link back to money worries.

Commercial sites were more likely to cite lack of knowledge as to what could be done as a principal barrier, while industrial sites were more likely to cite a lack of return on investment as a principal barrier across measure types. Industrial units were more likely to cite lack of money as a barrier to action for all measures aside from insulation.

Most of the commonly cited barriers – money, fears of poor return on investment, uncertainty about what can be done and how – could be addressed through a combination of funding mechanisms and tailored site reviews.

Overcoming lack of action on rented properties should involve targeting landlords rather than the resident businesses. Again, financial incentives may be an effective route.

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Appendices

Appendix 1: Review of previous estimates of the emissions within the unconstrained sector

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Appendix 1

Review of previous estimates of the emissions within the unconstrained sector

A number of previous studies have provided an estimate of the abatement potential from the unconstrained sector. The scope, methods and results from the most relevant studies are summarised below.

Policy options to Encourage Energy Efficiency in SME and Public Sector (NERA/Enviros, 2006)

Main findings

- Total emissions in the unconstrained sector of 39 Mt CO₂
- Cost-effective abatement potential of 4.5 Mt CO₂ in the unconstrained commercial and public sector by 2020
- Cost-effective abatement potential of 0.6 Mt CO₂ in the unconstrained industry sector by 2020
- 40 percent of the estimated cost-effective abatement is achievable from existing policies

Assumptions

- Base year of 2005
- Estimate of CRC coverage based on a 10,000 MWh threshold
- Cost-effective potential based on a 15% discount rate

NERA and Enviro (2006)⁴⁰ estimated the scale of emissions and abatement potential from organisations not covered by existing policies. The analysis was based upon abatement measures within the N-DEEM model (for the non-domestic buildings) and ENUSIM (for Industrial energy use). The cost-effective abatement potential was estimated for the industry, commercial and public sectors as a whole, and then a further estimate was made of the proportion of the savings that were attributable to different policy instruments (i.e. EU ETS, CCA and the CRC – previously termed the Energy Performance Commitment (EPC)). The estimated abatement potential in the unconstrained sector was therefore highly dependent upon the assumed allocation of emissions to the different policy packages.

The NERA/Enviro analysis estimated that the policy gap i.e. the size of the unconstrained sector, represented 19% of the total UK emissions from energy use within the commercial, industrial and public sector in 2005. This is equivalent 39 Mt CO₂. The analysis assumed that the CRC (then the EPC) was based upon a 10,000 MWh threshold, so higher than the threshold that has now been agreed.

In terms of the abatement potential, the NERA/Enviro analysis estimated a cost-effective abatement⁴¹ potential for commercial, industrial and public sector organisations of 20.5 Mt CO₂. This refers to a 15-year potential, i.e. what can be delivered in 15 years, so is consistent with an estimate of the potential that can be delivered by 2020. Of the total potential abatement, 5.1 Mt CO₂ was allocated to the unconstrained sector. This represents 13% of the total unconstrained emissions in the base year. Of the 5.1 Mt CO₂ of cost-effective abatement, 4.5 Mt related to abatement measures within the commercial and public sector and the residual for industrial energy use.

In addition to estimating the overall abatement potential, the NERA/Enviro work also examined the influence of existing and planned policies on the uptake of the abatement potential. It was estimated that a large proportion of the cost-effective potential that was available in the base year would be delivered by existing and planned policies, specifically the Building Regulations, Carbon Trust activities and Smart Metering. On this basis the remaining cost-effective potential in the unconstrained sectors, once the above policies were factored in, was estimated at between 3.0 – 1.9 Mt CO₂ by

⁴⁰ Policy Options to Encourage Energy Efficiency in the SME and Public Sectors . August 2006

⁴¹ Cost-effective abatement potential includes all measures with a positive Net Present Value at 15 percent discount rate

2020. This led the authors to conclude that the policy gap associated with the unconstrained sector is relatively small.

Review and update of UK abatement costs curves for the industrial, domestic and non-domestic sectors (AEA 2008)

Main findings

- Cost-effective abatement potential of 6.9 Mt CO₂ in the unconstrained commercial and public sector by 2022

Assumptions

- Cost-effective potential based on a 3.5% discount rate

To support its first report, the UK Committee on Climate Change commissioned AEA, with Ecofys and the Carbon Consortium, to review and update cost curves for energy end use sectors. The three main sector-based MACCs came from the ENUSIM model (industry sector) and BRE models – BREDEM (Domestic) and NDEEM (Non-domestic). BRE were first commissioned to update N-DEEM.

For non domestic buildings it was estimated that 13.2 Mt CO₂ of cost-effective abatement was technically possible, with a further 4.4 Mt CO₂ of abatement considered not cost-effective. This estimate was based on the cumulative savings delivered from measures in combination i.e. representing a conservative estimate of the abatement potential. It was based on a discount rate of 3.5% and excluded any hidden costs.

An initial estimate was made of the proportion of the abatement potential that related to organisations within the CRC, with the residual relating to the unconstrained sector. On this basis the cost-effective abatement potential for the unconstrained sector in 2022 was estimated as 6.9 Mt CO₂.

Uptake of energy efficiency in buildings (Element Energy 2009)

Main findings

- Cost-effective abatement potential of 5.3 Mt CO₂ in commercial sector businesses not covered by CRC, by 2022.
- Cost-effective abatement potential of 3.1 Mt CO₂ in the public sector by 2022.
- 46 percent of the estimated cost-effective abatement will be taken up in response to existing policies.

Assumptions

- Total abatement potential based on AEA/BRE analysis. Only technology penetration rates were updated as part of the study.
- Public sector abatement potential was not disaggregated into CRC and non CRC emissions.

Element Energy carried out an assessment of the potential for emissions savings from buildings, on behalf of the UK Committee on Climate Change. This included both domestic and non domestic buildings. The measures under consideration, and their associated maximum technical potential were defined using the N-DEEM model, based on the previous BRE/AEA analysis. No adjustments were made to the list of technologies or their potential savings. Instead the focus of the work was to update the assumed take-up of the measures by 2020.

The Element Energy analysis estimated that under the references scenario, i.e. without further policy intervention, 6.37 Mt CO₂ of cost-effective abatement potential will remain in the non-domestic buildings sector by 2022. This represents about half of the cost-effective potential available in 2007

(13.2 Mt CO₂)⁴². The analysis identified an additional 4.4 Mt CO₂ of abatement that was not considered to be cost-effective.

The abatement potential was also split into business covered by CRC, businesses not covered by CRC and public sector organisations. It was estimated that businesses not covered by CRC had a cost-effective potential in 2007 equivalent to 5.3 Mt CO₂, with the abatement potential remaining in 2020 under the reference scenario of 2.8 Mt CO₂. For the public sector, the abatement potential in 2007 was estimated as 3.1 Mt CO₂, with the remaining potential in 2020 estimated at 1.5 Mt CO₂. The public sector estimate was not split into CRC and non-CRC abatement.

The reference scenario used in the Element Energy analysis included policies that were firmly funded and committed prior to the 2007 Energy White Paper and as such did not include certain key policies introduced subsequently such as Smart Metering, or the RHI. However, some analysis of potential future policies was carried out to estimate what might realistically be delivered from policy interventions by 2020. Under a scenario that was developed to represent the most ambitious level of savings Element Energy estimated that over 9.3 Mt CO₂ of annual savings could be achieved by 2020, leaving around 3.8 Mt of potential unrealised.

Transforming the economic and carbon performance of the buildings we work in (Carbon Trust, 2009)

Main findings:

- Cost-effective abatement potential of 7.8 Mt CO₂ in commercial, public and industrial buildings not covered by CRC.

Assumptions:

- Base year of 2006.
- Non-CRC organisations were assumed to cover 50% of the CO₂ reduction potential from existing buildings.

The Carbon Trust carried out a detailed analysis of the non-domestic building sector and assessed the steps required to deliver a low carbon building stock by 2050. The analysis carried out an assessment of the current emission from the current stock, and then developed scenarios of the potential reductions in emissions that could be delivered from the sector. This took into account energy efficiency measures, but also alternative energy sources and the impacts of decarbonisation of the grid. The analysis also took into account both existing and new build premises, accounting for demolition of the existing stock and standards for new build.

The assessment of the cost-effective abatement potential for the non-domestic stock was estimated based on abatement measures in the NDEEM model. For those existing buildings which will still be standing in 2020, the Carbon Trust analysis assumed a ~15% carbon reduction potential from cost-effective energy efficiency measures, which if implemented would reduce emissions by 15.6 Mt CO₂. This estimate was made relative to 2006 baseline level of emissions, and included commercial and public sector buildings, plus the building-related emissions from industrial activities.

The emissions saving estimate was validated against data that were held by the Carbon Trust on the energy savings potential identified from individual site audits. The site audit data were comparable with the NDEEM modelling, with potential carbon reduction of 12% for commercial organisations, and 13% for the public sector. Further validation was carried out with evidence from the Carbon Trust's Low Carbon Buildings Accelerator, which indicated emissions savings in line with the conclusions from the NDEEM model.

In the Carbon Trust analysis, non-CRC organisations were assumed to cover 50% of the CO₂ reduction potential from existing buildings. On this basis the abatement potential from non domestic buildings in the unconstrained sector was estimated at 7.8 Mt CO₂/year by 2020. The analysis did not consider in detail the take-up of measures in response to existing policies, although an extended version of Carbon Trust's loans for SMEs was estimated to deliver 2.4 Mt CO₂/year by 2020.

⁴² This is effectively the same as the results from the BRE/AEA analysis, since the Element Energy study was focused on the uptake of measures in the future.

Potential for energy efficiency savings in small and medium sized organisations – Preliminary Assessment (BRE, 2009)**Main findings:**

- Cost-effective abatement potential of 7.3 Mt CO₂ in the unconstrained commercial and public sector⁴³.
- Cost-effective abatement potential of 6.9 Mt CO₂ in the unconstrained industrial sector⁴³.

Assumptions:

- Assumed that the energy consumption per employee within each sector is independent of organisation size.

BRE (2009) carried out an analysis of the energy use patterns of organisations and the potential for energy efficiency savings that exists in those which are not covered by existing policies i.e. the unconstrained sector. The analysis was again based on existing energy models of the UK building stock (N-DEEM) and industrial energy use (ENUSIM). The consumption patterns were revised to match current consumption levels and results of the original cost abatement adjusted to take account of prevailing rates of uptake of energy efficiency measures.

Energy use from the public, commercial and industrial sectors was based on DUKES (2008) energy consumption data. This was then disaggregated to end-user according to the proportions predicted by the N-DEEM and ENUSIM models. Using BERR statistics on the size breakdown of UK companies by number of employees, and by assuming that the energy consumption per employee within each sector is independent of organisation size, the size of company reaching the CRC qualification threshold for electricity consumption is estimated. All organisations of smaller size than this are assumed to belong to the unconstrained sector and therefore their emissions are used for the basis of the policy gap.

The results of this analysis indicate that the cost-effective potential for energy efficiency savings is 92 TWh/year of which 48% (44 TWh) was estimated to fall within the unconstrained sector. In terms of CO₂ emissions this equates to 30 Mt CO₂ of cost-effective abatement in total, with 14.2 Mt CO₂ of potential in the unconstrained sector. For the unconstrained sector, this suggests that 15.7% of the base year emissions could be saved by cost-effective abatement measures.

Further analysis of the BRE results indicates that 14.3 Mt CO₂ of the abatement potential could be allocated to the commercial and public sectors and 16.2 Mt CO₂ to industrial activities. In terms of the unconstrained sector, 7.3 Mt CO₂ of abatement potential were identified for the commercial and public sectors and 6.9 Mt CO₂ for industrial activities. This suggests a relatively even split between the two sectors in absolute terms. However, in relative terms the public and commercial sectors have a greater potential per unit of emissions (19%) than the industry sector (13%).

⁴³ The results have been estimated by AEA based upon BRE data

Appendix 2

Methodology for determining the energy use and emissions from the sector

Estimation methodology

The estimation methodology for energy use within the unconstrained industry and service (i.e. public and commercial) sectors involves firstly the determination of the total UK energy consumption for the relevant sectors. Then, energy consumption that is covered by existing policies is estimated and subsequently excluded to leave a residual which represents the unconstrained sector. The following sections describe the datasets used and methodology employed in each of the calculation steps.

Industry

The total UK industry and service sector energy consumption is estimated from the Digest of UK Energy Statistics (DUKES)^{44,45}. For industry, the subsector disaggregation is taken from DUKES Table 1.1 Aggregate energy balance for 2008. For the public, commercial and agriculture sectors, the total energy demand is also taken from DUKES Table 1.1. However, the subsector disaggregation for public administration and commercial is based upon the splitting ratios derived by SKM Enviros (2010).

The DUKES aggregate energy balance table gives final consumption of energy split by fuel and main industry sector. In addition, it also gives details of transformations of energy from one form to another and energy consumed by energy industries. There are only two industrial processes listed in the transformations and energy industries subsections; coke manufacture and blast furnaces. Here we define both these processes as being components of the iron and steel sector and therefore combine the primary energy consumption of these processes with the final energy consumption for the iron and steel sector. The transformation of energy subsection shows primary energy consumed and energy contained in the manufactured products, so for coke manufacture this is coal fed into the process and coke or coke oven gas produced. For blast furnaces, the manufactured product is blast furnace gas. The energy contained in these manufactured products is excluded in our analysis to avoid double counting since we have already accounted for the energy content of the input fuels.

The 'unclassified' industry sector represents energy consumption where the data supplier has been unable to allocate an amount between categories, and where the Department of Energy and Climate Change does not have additional information available to assign the energy consumption. Here, we have allocated the unclassified sector fuel consumption between the other remaining industry sectors in proportion to their current consumption of each fuel type relative to the total consumption across identified industry sectors.

Where heat is consumed by an industry sector, we convert this to primary fuel consumption by pro-rating the fossil fuels consumed in the heat generation section of the energy balance according to the ratio of the heat consumed in each sector and the heat produced through transformation processes.

Similarly, auto-production of electricity is accounted for using data from DUKES Table 1.9, which details fuels consumed for autogeneration and the consumption of own generation electricity split by the main industrial groups: iron and steel and non-ferrous metals; Chemicals; Metal products, machinery and equipment; Food, beverages and tobacco. The fuel consumed for autogeneration is added to the consumption of the relevant sector, while the own generation electricity consumed is removed from the sector electricity consumption. It is assumed here that all coal consumed in autogeneration in the iron, steel and non-ferrous metals sector can be attributed to the non-ferrous metals sector, since the UK's largest autogenerator is Alcan, who have a power station in the North East to supply electricity for their aluminium smelter. All remaining autogeneration fuel consumption is assigned to iron and steel. Own generation electricity consumed is split between non-ferrous metals and iron and steel according to the ratio of primary energy consumed.

⁴⁴ <http://www.decc.gov.uk/en/content/cms/statistics/publications/dukes/dukes.aspx>

⁴⁵ <http://www.decc.gov.uk/en/content/cms/statistics/publications/ecuk/ecuk.aspx>

Having established the energy consumption of the sector split by fuel type, sectoral emission estimates are generated by multiplying energy consumption by emission factors drawn from the inter-departmental Analysts Group⁴⁶. The energy consumption statistics published in DUKES and ECUK are expressed in Gross Calorific Value (GCV) terms and the corresponding GCV emission factors (EFs) are chosen (Table A 1) EFs are consistent across the industry and services sector analyses.

Table A 1: Emission Factors used in this analysis⁴⁷

Fuel	Emission factor (kt CO₂/GWh)
Electricity	0.541
Natural gas	0.184
Petroleum products (assumed to be represented by fuel oil)	0.2
Solid fuel (assumed to be represented by industrial coal)	0.3

Public and commercial sector

Energy consumed in the public administration, commercial and agricultural sectors is also published in DUKES table 1.1. Energy consumed in the public administration and commercial sectors is broken down further in the same proportions as; the emissions breakdown used by SKM Enviros (2010)⁴⁸, with public administration split between:

- Education.
- Government.
- Health.

While commercial sector energy consumption is broken down between:

- Commercial offices.
- Communication and transport.
- Hotel and catering.
- Other.
- Retail.
- Sport and leisure.
- Warehouses.

We recognise that there is likely to be an amount of autogeneration occurring within the non-domestic buildings sector and therefore we have taken the information provided in the footnote to DUKES Table 1.9 which relates to energy consumed in autogeneration for transport, commerce, administration and services. We assume that the energy consumed for autogeneration in the service sector is in the form of natural gas, which is assigned according to the consumption within each subsector relative to the total for services. Consumption of own generation electricity is assigned using the same proportions.

For the agriculture sector, energy consumption is detailed in DUKES Table 1.1.

As for the industry sectors, energy consumption values are converted to emissions using the coefficients listed in Table A 1.

Total energy consumption in industry and services split by fuel and main sector is shown in the table below.

⁴⁶ http://www.decc.gov.uk/en/content/cms/statistics/analysts_group/analysts_group.aspx

⁴⁷ Source: Defra/DECC's GHG Conversion Factors for company reporting

⁴⁸ SKM ENVIROS – CRC Cap setting study for the CCC (2010)

Table A 2: 2008 UK energy consumption in Industry and services split by fuel and main sector

Sector	Coal	Petroleum products	Natural gas	Electricity	Total
Industry	98,141	50,266	197,822	82,810	429,039
Iron and steel	59,701	3,180	8,210	4,890	75,981
Non-ferrous metals	9,545	543	3,303	3,087	16,478
Mineral products	8,830	2,016	11,091	7,756	29,693
Chemicals	3,311	2,370	51,331	15,738	72,750
Mechanical engineering, etc	121	1,210	8,713	7,841	17,886
Electrical engineering, etc	46	542	3,897	6,979	11,464
Vehicles	395	1,348	8,635	5,595	15,972
Food, beverages, etc	370	3,316	30,239	10,712	44,638
Textiles, leather, etc	622	1,211	6,101	3,184	11,117
Paper, printing, etc	1,535	767	20,401	9,770	32,472
Other industries	13,666	31,914	43,319	5,753	94,652
Construction	-	1,848	2,583	1,505	5,937
Services	1,145	16,736	240,516	72,062	330,460
Commercial Offices	14	859	24,477	9,830	35,180
Communication and Transport	6	382	10,879	4,369	15,635
Education	135	743	10,683	2,043	13,604
Government	696	3,838	55,197	10,554	70,285
Health	202	1,114	16,025	3,064	20,405
Hotel and Catering	18	1,145	32,636	13,107	46,906
Other	-	1,410	9,033	-	10,443
Retail	32	2,004	57,113	22,937	82,086
Sport and Leisure	-	1,410	9,033	-	10,443
Warehouses	5	286	8,159	3,277	11,727
Agriculture	39	3,545	7,282	2,881	13,746

EU ETS energy consumption

EU ETS energy consumption has been calculated from two sources. The first is from Community Independent Transaction Log (CITL) reported fuel consumption for 2008 aggregated to the sector level (where possible). These data were available for the following sectors:

- Non-ferrous metals.
- Chemicals.
- Food, beverages, etc.
- Paper, printing, etc.
- Mineral products and other industries.

For the remaining sectors, where no CITL reported fuel splits were available or where energy consumption data did not agree with verified emissions assigned to the sector, the emissions data are converted to energy consumption according to the sector fuel splits reported under CCAs. This represents a best approximation to the fuel mix consumed in EU ETS organisations since CCA organisations are also energy intensive operations and in many cases, there is overlap between the two policies. However, this approach does introduce an error since the mix will differ from that reported under EU ETS. Energy use split by fuel and sector is shown in Figure A 1. It should be noted that there are sectors where the larger sites reporting under EU ETS will be of a different nature to the smaller sites covered by CCA. A good example of this is iron and steel: EU ETS is largely represented by three integrated steelworks, while CCA will also cover electric arc steelworks, and numerous sites re-melting steel to make products such as sheets or bars.

Primary energy consumed by EU ETS power generation plants is not included in this analysis since our total energy consumption does not include (except for industry autogeneration) energy consumed for transformation of primary fuels to electricity.

EU ETS energy consumption is detailed in terms of direct fuels only. Although electricity is assumed to be covered by EU ETS, we do consider electricity consumption in the CCA and CRC coverage

since we are interested to demonstrate the energy consumed in the unconstrained sector, i.e. the quantity of electricity consumed by organisations not current affected by climate change policy and therefore with potential to reduce their electricity consumption.

Figure A 1: EU ETS energy consumption in 2008 split by fuel and sector

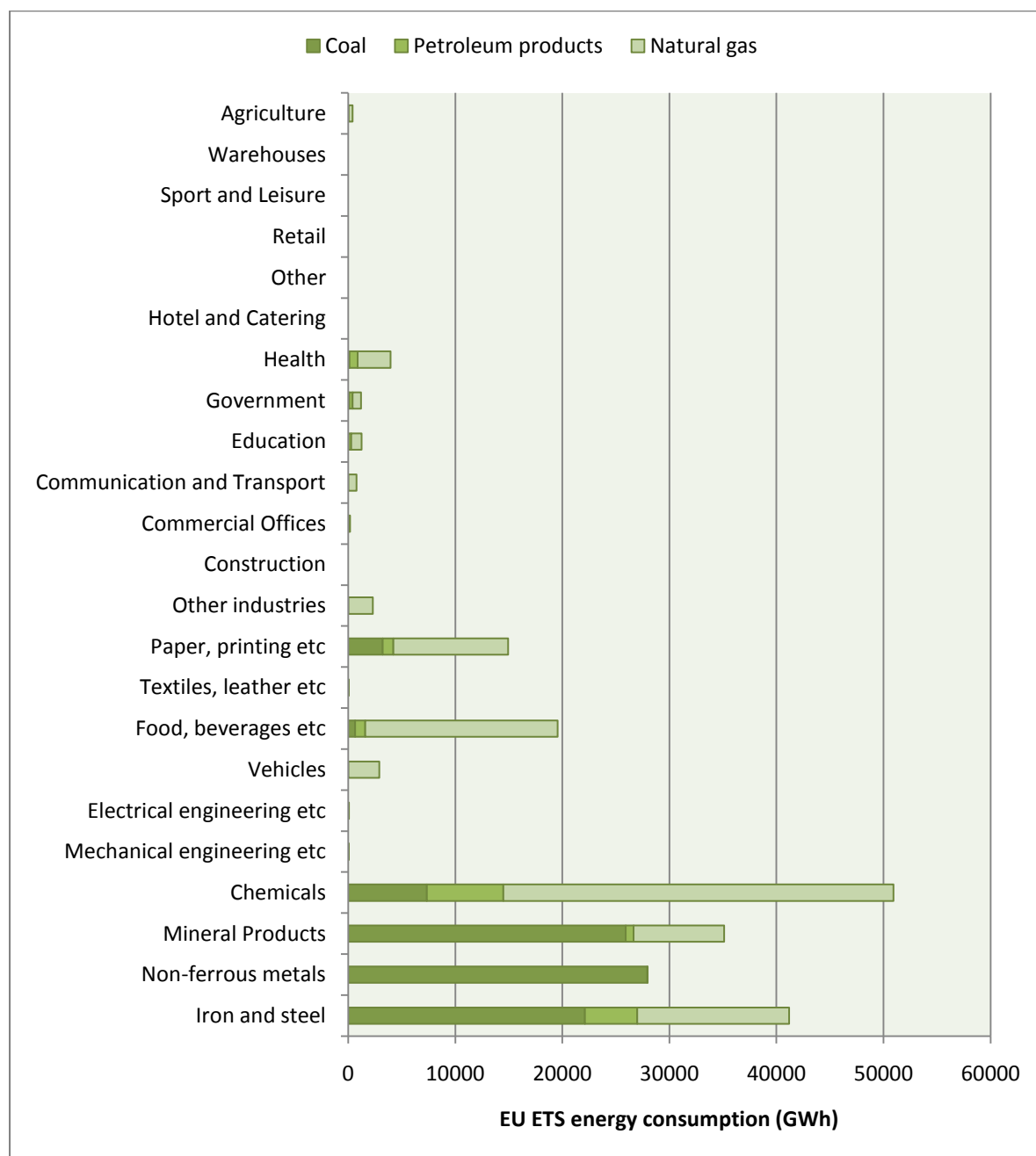


Table A 3: 2008 energy consumption under the EU ETS split by main sector and fuel type

GWh	Coal	Petroleum products	Natural gas	Total
Unclassified	0	0	0	0
Iron and steel	22116	4897	14173	41186
Non-ferrous metals	27947	0	1	27948
Mineral products	25922	746	8468	35136
Chemicals	7359	7153	36444	50957
Mechanical engineering etc	0	0	65	65
Electrical engineering etc	0	4	66	70
Vehicles	0	21	2889	2910
Food, beverages etc	669	921	17991	19581
Textiles, leather etc	1	3	49	54
Paper, printing etc	3236	1002	10699	14938
Other industries	0	18	2283	2301
Construction	0	0	0	0
Total	87251	14766	93128	195145
Commercial offices	6	38	150	194
Communication and transport	2	32	744	778
Education	38	246	972	1256
Government	103	327	787	1217
Health	119	779	3076	3973
Hotel and catering	0	0	0	0
Other	0	0	0	0
Retail	0	0	0	0
Sport and leisure	0	0	0	0
Warehouses	0	0	0	0
Agriculture	24	18	383	425

There are some issues relating to EU ETS data that we are aware of, but have been unable to resolve fully within the scope of this project:

- CITL emission totals will include both combustion related CO₂ and process related. The process emissions will include, for example, CO₂ from calcinations during clinker manufacture which will be a significant proportion of CO₂ from cement works. For the cement sector we take reported fuel consumption from the CITL and remove the emissions associated with clinker production.
- EU ETS will include some fuels that are not included in the DUKES energy balance. Most important perhaps is petroleum coke which is used by the cement industry and a few other operators. Some process wastes used as fuels may also be outside the scope of DUKES.

CCA sector level energy consumption

Fuel consumption aggregated at the CCA sector level has been provided by DECC based on:

- Reported CCA energy use (CCA10 data at MS4).
- Fuel splits from CCA facilitators.
- ECUK Table 4.6.

CCA10 data reflect the population of the CCAs as at the end of each sector's respective fourth target period, as reported to DECC on 9 February 2009.

Fuel consumption data are aggregated to the analysis sectors based on expert judgement from CCA facilitators. Energy consumption is then converted to emissions using the emission coefficients listed in Table A 1.

Figure A 2: CCA energy consumption, split by fuel and analysis sector. Representative of 2008

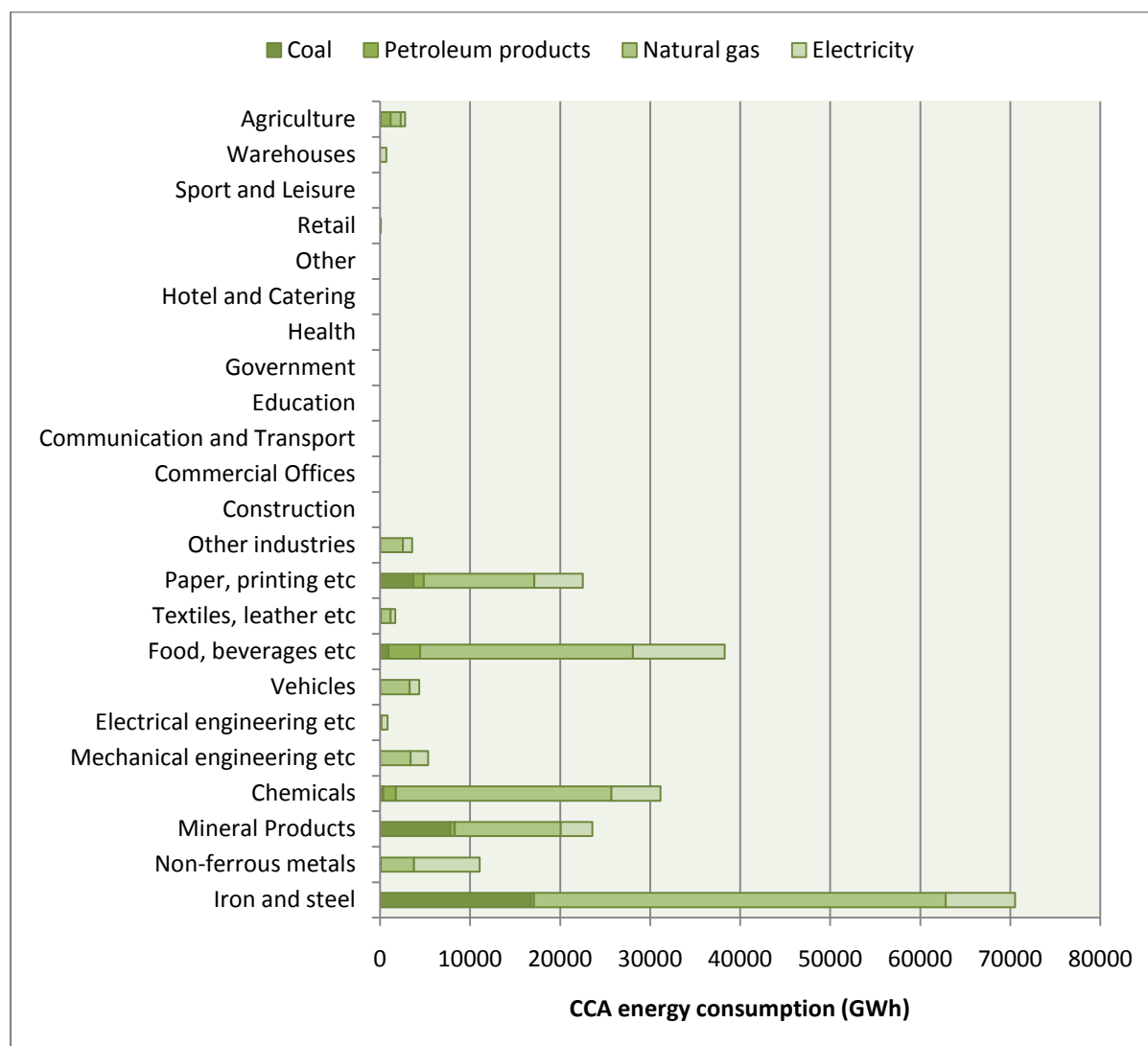


Table A 4: Energy consumption under CCAs. Representative of 2008

GWh	Coal	Petroleum products	Natural gas	Electricity	Total
Unclassified	0	0	0	0	0
Iron and steel	16759	362	45706	7720	70548
Non-ferrous metals	0	103	3693	7298	11094
Mineral Products	7819	495	11770	3512	23595
Chemicals	376	1400	23919	5480	31175
Mechanical engineering etc	4	12	3404	1942	5362
Electrical engineering etc	0	12	173	666	851
Vehicles	0	28	3296	1045	4369
Food, beverages etc	947	3533	23600	10225	38305
Textiles, leather etc	24	74	1108	492	1698
Paper, printing etc	3717	1151	12289	5389	22547
Other industries	0	20	2532	1018	3570
Construction	0	0	0	0	0
Commercial offices	0	0	0	0	0
Communication and transport	0	0	0	0	0
Education	0	0	0	0	0
Government	0	0	0	0	0
Health	0	0	0	0	0
Hotel and Catering	0	0	0	0	0
Other	0	0	0	0	0
Retail	0	0	3	104	107
Sport and Leisure	0	0	0	0	0
Warehouses	0	0	0	714	0
Agriculture	70	1112	1122	488	2792

Since many CCA target units, are covered by both EU ETS and CCAs, it is important that the overlap between the two policies is removed from this analysis. Data on the traded (i.e. EU ETS covered) direct energy consumed within CCA sectors have been provided by DECC based primarily on CCA10 reported energy consumption, but also using information from:

- CCA sector facilitators.
- ECUK - Table 4.6.
- CCA application.
- 2002 CCA submission.

However, the overlap energy is not broken down by fuel type and we therefore estimate this breakdown using the CCA energy consumption split (as shown in **Error! Reference source not found.4**).

Both CCA fuel split and overlap data may be estimates and we highlight a further uncertainty in breaking down the overlap energy estimate using the CCA fuel consumption split. As a result, there is some uncertainty around the consistency between the two datasets, for example, in the Non-Ferrous metals sector the overlap estimate for natural gas is higher than that for CCA consumption.

Having removed EU ETS and CCA energy, total energy consumed in industry falls below that consumed in the services sector buildings, which reflects the industry focus of these policies. However, we note some anomalous results where a negative residual is found. This is predominantly in the industry sectors and is symptomatic of inconsistent alignment between the datasets used both in terms of the fuel splits and the aggregation of installation of target unit into analysis sector. EU

ETS and CCA datasets can be very precisely allocated to sectors. On the other hand, energy statistics in DUKES are estimated (at the detailed level) although overall fuel demand figures are very accurate. Therefore, the negative residuals are indicative of the uncertain nature of the overall energy data at the detailed sector level. To reconcile these anomalies, we make use of a level of expert judgement, informed by the EU ETS and CCA energy consumption calculations detailed above, together with industry consultation and alternative estimates (e.g. SKM ENVIROS (2010)) to adapt the proportion of DUKES energy consumption that is estimated to be covered by EU ETS and CCAs. This process is only completed for those industry sectors where a negative residual is found and the coverage proportion assumed is listed in Table A 5.

Table A 5: Assumed coverage of DUKES energy consumption by EU ETS and CCAs

Sector	Assumed EU ETS CCA coverage proportion (%)
Iron and steel	0.75
Non-ferrous metals	0.78
Mineral products	0.78
Chemicals	0.78
Food, beverages etc	0.78
Paper, printing etc	0.77
Other industries	0.25
Agriculture	0.23

CRC coverage

Energy consumption under the CRC is based on the coverage estimate by SKM Enviros (2010). The underlying DUKES energy consumption used in the SKM Enviros study is the same as that used here, however, the value of the residual energy use - following removal of EU ETS and CCA energy use - is achieved using a different methodology. To ensure a degree of consistency between the two studies, the relative proportion of the residual covered by CRC as estimated by SKM Enviros (2010) is applied to the residual calculated here. Therefore, while the absolute values for the size of the unconstrained sector are not identical, the relative proportion of the sector (once overlaps with EU ETS and CCAs are accounted for) is consistent. This relative scaling is justified because the CRC coverage must be related to the energy consumption falling outside EU ETS and CCA, if the residual increased because EU ETS and CCA coverage decreased, then more energy consumption would qualify for CRC.

The CRC provides three CCA related exemptions:

1. for the whole CRC organisation if it is a single entity and possesses a CCA covering more than 25% of the organisations energy use;
2. for a subsidiary organisation if that organisation has a CCA that covers more than 25% of its energy consumption;
3. Finally, if after removing energy use associated subsidiaries through CCA exemptions, the residual electricity consumption of a CRC organisation through HHMs is less than 1,000 MWh, then the entire organisation will be exempt from CRC.

An estimate of the CCA exclusion from CRC has been calculated from a dataset of electricity consumption through Half Hourly Meters (HHMs) provided by the Environment Agency. The dataset details all electricity consumption through HHMs in 2008 in the UK and has been processed by the EA to assign a Standard Industry Classification (SIC) code to the activity for which the electricity was used and also to aggregate the electricity consumption to the highest parent organisation.

To estimate the CRC covered electricity consumption by industry or service sector, we sum electricity consumption across meters falling into each respective sector and where the parent organisation responsible for the meter qualifies for the CRC (i.e. the consumption through all HHMs for that organisation is greater than 6,000 MWh).

The CRC does not cover energy already covered by EU ETS or CCAs. To identify HHMs that are covered by EU ETS or CCAs we cross referenced the company name owning the meter and the

meter address with that of CCA target units and of installations in the EU ETS. Where a match is found we flagged up that the meter is covered by CCA, EU ETS or both.

Calculating specific CCA exemptions has not been possible within this study due to the complexity of the calculations required, instead, we assume two cases to represent bounds to the exemption:

1. that where a HHM is found to be covered by a CCA, the electricity consumed through it is exempt. This represents an underestimate of CCA exclusion.
2. Where a HHM is found to be covered by a CCA, the electricity consumed through any HHM owned by the same organisation is exempted. This represents an overestimate of CCA exclusion.

When comparing the two cases above we find that case 2 excludes on average 40% more electricity consumption than case 1. Using this as a guide, we assume that a further 20% of CCA covered energy consumption would be excluded from the CRC as a result of exemptions.

Table A 6: Proportion of 2008 energy consumption covered by EU ETS and CCAs

Sector	Proportion of the sector covered by EU ETS and CCAs (%)
Industry	69%
Iron and steel	90%
Non-ferrous metals	94%
Mineral Products	94%
Chemicals	94%
Mechanical engineering, etc	36%
Electrical engineering, etc	9%
Vehicles	41%
Food, beverages, etc	94%
Textiles, leather, etc	19%
Paper, printing, etc	92%
Other industries	30%
Construction	0%
Services	4%
Commercial offices	1%
Communication and transport	6%
Education	10%
Government	2%
Health	22%
Hotel and catering	0%
Other	0%
Retail	0%
Sport and leisure	0%
Warehouses	7%
Agriculture	24%

**Table A 7: Residual energy consumption (GWh) after removal of EU ETS and CCA energy use.
representative of 2008**

Sector	Coal	Petroleum products	Natural gas	Electricity	Total
Industry	18,213	29,252	57,751	27,775	132,991
Iron and steel	5,970	318	821	489	7,598
Non-ferrous metals	611	35	211	198	1,055
Mineral products	565	129	710	496	1,900
Chemicals	212	152	3,285	1,007	4,656
Mechanical engineering, etc	116	1,195	4,551	5,511	11,373
Electrical engineering, etc	46	529	3,703	6,180	10,458
Vehicles	395	1,315	3,341	4,340	9,392
Food, beverages, etc	24	212	1,935	686	2,857
Textiles, leather, etc	592	1,120	4,736	2,594	9,041
Paper, printing, etc	117	58	1,550	743	2,468
Other industries	9,566	22,340	30,324	4,027	66,256
Construction	-	1,848	2,583	1,505	5,937
Non-domestic buildings	812	14,052	231,628	70,286	316,778
Commercial offices	7	813	24,297	9,830	34,946
Communication and transport	3	343	9,986	4,369	14,701
Education	89	448	9,517	2,043	12,097
Government	572	3,446	54,252	10,554	68,824
Health	59	180	12,334	3,064	15,637
Hotel and catering	18	1,145	32,636	13,107	46,906
Other	-	1,410	9,033	-	10,443
Retail	32	2,004	57,109	22,813	81,957
Sport and leisure	-	1,410	9,033	-	10,443
Warehouses	5	286	8,159	2,420	10,870
Agriculture	28	2,567	5,272	2,086	9,952

Table A 8: Residual energy consumption (GWh) attributed to the unconstrained sector i.e. energy consumption after removal of EU ETS, CCA and CRC energy use. Representative of 2008

Sector	Coal	Petroleum products	Natural gas	Electricity	Total
Industry	6,237	12,978	24,595	11,731	55,540
Iron and steel	1,194	64	164	98	1,520
Non-ferrous metals	122	7	42	40	211
Mineral products	113	26	142	99	380
Chemicals	106	76	1,643	504	2,328
Mechanical engineering, etc	58	598	2,276	2,755	5,687
Electrical engineering, etc	23	265	1,852	3,090	5,229
Vehicles	119	395	1,002	1,302	2,818
Food, beverages, etc	7	64	581	206	857
Textiles, leather, etc	177	336	1,421	778	2,712
Paper, printing, etc	23	12	310	149	494
Other industries	4,294	10,029	13,613	1,808	29,743
Construction	-	1,109	1,550	903	3,562
Services	253	6,309	92,085	28,727	127,374
Commercial offices	3	406	12,148	4,915	17,473
Communication and transport	2	172	4,993	2,185	7,351
Education	36	179	3,807	817	4,839
Government	147	887	13,962	2,716	17,712
Health	24	72	4,934	1,226	6,255
Hotel and catering	11	687	19,582	7,864	28,144
Other	-	705	4,516	-	5,222
Retail	9	556	15,857	6,334	22,756
Sport and leisure	-	705	4,516	-	5,222
Warehouses	2	143	4,080	1,210	5,435
Agriculture	20	1,797	3,690	1,460	6,967

Appendix 3

Review of the abatement potential estimated by N-DEEM

The accuracy of the N-DEEM results have been examined by making comparisons with results from alternative sources. A tiered approach has been adopted. This provides the flexibility to enable the results of N-DEEM to be compared against a range of alternative evidence, at different levels of resolution. The different tiers are:

- Tier 1: Estimated abatement potential from the non-domestic building stock as a whole.
- Tier 2: Estimated abatement potential from different sectors, or segment of the non-domestic building stock.
- Tier 3: Estimated abatement potential from individual measures, or groups of measures within the existing non-domestic building stock.

At a Tier 1 level no differentiation is made between the abatement measures that are applied, or the sectors concerned. This therefore provides a comparison of the savings potential at the very highest level. Further refinement is allowed for in the other Tiers, with Tier 2 taking into account sectoral differentiation in the savings potential, and Tier 3 allowing for differences in the abatement potential that can be delivered by different measures.

Data sources

To assess the accuracy of the results of the NDEEM model, evidence has been sought from a range of sources. This includes results from alternative models of the building stock, but also evidence from specific programmes or policies that have been set up to drive the uptake of abatement measures. Since few existing studies have considered the unconstrained sector specifically, most of the data relate to non-domestic buildings generally.

The following key datasets have been used to assess the accuracy of the data:

- **Carbon Trust's Close Out Database.** The Carbon Trust has collected data on every carbon reduction measure recommended to the organisations it has worked with directly. This includes following up with these organisations to find out which measures have been implemented. The abatement measures have been identified at an individual site level, and have been categorised using a standardised taxonomy of measures, and assessed using agreed energy price assumptions and emissions factors. Therefore, while the measures may have been identified by different individuals with different areas of expertise, as far as possible the approach has been harmonised to allow a consistent and comparable set of results. The results from the site audits, and subsequent follow-ups, are stored centrally in the Carbon Trust's 'Close Out' database.
- **Carbon Trust's Low Carbon Buildings Accelerator (LCBA).** As part of the LCBA the Carbon Trust examined 10 large scale refurbishment projects to understand how carbon emissions can be reduced. These projects covered both public and private sector buildings with various uses including retail, hospitality, offices and accommodation.
- **Carbon Trust's Advanced Metering field trial for SMEs.** From 2004 to 2006 the Carbon Trust carried out the first UK field trial of advanced metering for SME users. The trial aimed to demonstrate the potential benefits of the technology and to understand the case for encouraging widespread adoption of advanced metering by SMEs. A total of 582 advanced meters were installed in SMEs across the UK and metering services were provided to these sites by seven different consortia.
- **Market Transformation Programme (MTP).** The Market Transformation Programme (MTP) supports sustainable consumption and production, in particular policies and delivery programmes which encourage competition and innovation in the environmental performance

of energy using products. MTP collates data and develops scenarios on the uptake, performance and cost for a range of domestic and commercial products.

Most of these datasets, with the exception of the MTP modelling, provide bottom-up estimates of the abatement potential based upon real site data. The savings therefore represent estimates for specific measures at specific sites.

In addition to the above, several other data sources were identified and collated for the purposes of the validation. This included data, for example, from the Energy Saving Trust's EEAC Advice Service and the EPSRC and Carbon Trust funded Tarbase project on abatement technologies for buildings. It also includes data from initiatives run by the UK Regional Development Agencies. While these data sources have provided a useful understanding of the issues, and also to some extent the abatement potential, the data were generally not in a format where they could be easily used to validate the NDEEM outputs. However, where appropriate these other datasets have been used to cross-check the overall conclusions.

Methodological issues

Even with the flexibility of the tiered framework, methodological differences make direct like-for-like comparisons between N-DEEM and alternative sources difficult. In particular, the following factors need to be taken into account when comparing the results from different studies:

- **Measures data.** The analysis within N-DEEM draws upon a list of around 80 different abatement measures. The primary data are based on an extensive review that was carried out by BRE as part of the initial model development. The results from the alternative estimates are typically not based on such a prescriptive list of measures, or a standardised set of performance criteria. This means that while the high level measures description e.g. heating, lighting technologies is reasonably comparable, the individual technology assumptions cannot be so easily compared.
- **Measures interaction.** An important consideration when considering the performance of multiple measures is measures interaction. This is explicitly accounted for in the modelling approach used within N-DEEM, by assessing measures in combination. In the case of the site surveys while measures interaction is not explicitly considered, the savings are estimated relative to a site-specific baseline – so already take into account interaction with the existing measures.
- **Scope of assessment.** In N-DEEM energy saving estimates are made for each of the different measures in each of the different hereditaments. The implication is that savings are identified for the 'big' measures, but also a whole series of smaller measures. The approach in the site audits is different. The focus is typically on the most important measures – the audits are unlikely to identify a list of measures as extensive as N-DEEM. In addition, the audits may have a natural bias toward shorter term low cost measures as these can be more easily be taken up by the client than measure with higher capital cost.
- **Analytical framework.** In N-DEEM all of the measures are assessed using a consistent analytical framework. The same level of consistency cannot be assumed for the bottom-up site data. While standardised data capture frameworks (such as those used by the Carbon Trust⁴⁹) can improve the consistency, the assumed energy savings are largely based on the expert assessment of the auditors.
- **Methodological assumptions.** There is a raft of methodological assumptions that would lead to inconsistencies in the estimated savings from the different measures. Of particular importance is the choice of discount rates⁵⁰, the choice of emissions factors, the fuel mix assumptions, the fuel price assumptions and the inclusion of other subsidies and incentives. In the N-DEEM model these parameters are all fixed and can be adjusted to reflect current assumptions. The methodological assumptions used in the site audits are typically standardised, but these factors may change over time.
- **Base year.** The N-DEEM analysis is based on the energy use characteristics of a sample of hereditaments in the late 1990s. The uptake of abatement measures, and the current energy use characteristics, are modelled – taking into account historical trends - and calibrated with top-down statistics for the current year. In contrast, the site surveys represent the current mix of technologies and energy use characteristics of the sites that have been sampled.
- **Technical Vs realistic potential.** The N-DEEM analysis estimates the abatement potential that is technically potential i.e. all abatement that technically could be implemented. This does not take into account the time it would take to implement all of the technical potential, or the full range of

⁴⁹ It is also worth noting that the data used in this study from the Carbon Trust's Close Out database has also gone through the Carbon Trust's own quality checking procedures,

⁵⁰ Higher discount rates lead to lower cost-effective potential (due to higher costs of capital)

barriers to uptake. In contrast, the estimates made by the site surveys are more likely to represent a realistic potential – the measures identified represent measures that the organisations could realistically implement within their current business investment cycle.

While the above factors mean that the direct comparison of the results from N-DEEM with those from alternative studies is not straightforward, understanding these issues is itself important when assessing the overall accuracy of the results.

In particular, it is important to recognise that the different sources of evidence have their own strengths and weaknesses. The bottom-up site audits benefit from an extensive dataset of measures from a large number of different sites and sectors. They also reflect the actual up-to-date mix of technologies and energy demand characteristics at the sites. However, the savings identified in the site surveys may only capture a proportion of the total savings from a given site – albeit the most promising measures. There are also challenges associated with ensuring the consistency of the estimates, and also aggregating up the site-level data to enable a UK wide estimate. In contrast, the standardised approach used in N-DEEM has clear benefits from a policy modelling perspective. However, it is also apparent that the underlying data that underpins N-DEEM analysis have some significant limitations. Specifically, the model is based on site audits and technology assessments that were carried out a numbers of years ago and there are questions over the reliability of these estimates when applied to the current building stock. In addition, by reflecting the technical potential the N-DEEM analysis may not adequately reflect the realistic uptake of measures.

The implication of these differences in data and methods on the results generated from the different studies is examined below.

Tier 1: Estimated savings that can be achieved by all abatement measures within the non-domestic building stock

This provides the highest level analysis. It allows the overall results from N-DEEM to be compared, in aggregate terms, with the findings from other studies that have examined the abatement potential from non-domestic buildings.

Abatement potential is estimated in N-DEEM using a Marginal Abatement Cost Curve (MACC) tool. This tool provides an estimate of the costs and overall savings from a range of abatement measures⁵¹ when applied to the UK non domestic building stock. The MACC tool was last updated by BRE, and modified by AEA, for the Committee on Climate Change in 2008. For the purposes of the current comparison the results from AEA (2008) analysis have been used. No adjustments have been made to the energy price assumptions or emissions factors as part of the comparison⁵². The results presented are therefore consistent with the original analysis.

The results from the AEA (2008) analysis of the abatement potential from the public and commercial sector building is summarised below. Results for the cost-effective potential are presented based on social discount rate of 3.5% (as reported in the original work) and also at a private discount rate of 10% - which is comparable with the rate used in the Carbon Trust analysis described below. In practice, the overall cost-effective abatement potential appears relatively insensitive to this change in the discount rate.

Table A 9: Abatement potential for non-domestic sector, Mt CO₂

	Total abatement potential	Total cost-effective abatement potential (3.5%)	Total cost-effective abatement potential (10%)
Measures in isolation	26.54	20.03	19.56
Combined measures	17.62	13.21	13.09

Notes: Estimate based on energy efficiency measures only, so excludes renewable energy

It was estimated that 17.7 Mt CO₂ of abatement could be delivered from measures within public and commercial sector buildings, by 2020. This estimate represents the technical potential, after allowing for the business-as-usual penetration of technologies that would have happened anyway. However, the technical potential does not necessarily represent what a realistic level of uptake of measures

⁵¹ In the analysis that was carried out for the CCC, Combined Heat and Power (CHP) was removed from the list of measures and assessed separately by AEA.

⁵² While ideally these methodological parameters would have harmonised across all of the studies compared this was not possible. In some cases the underlying methodological parameters were not known.

may be⁵³, if policies were put in place to drive uptake. Of the total abatement, an estimated 13.1 Mt CO₂ of savings were identified as cost-effective (i.e. the net benefit from the energy savings was larger than the net cost of the measures, when discounted at a 10% discount rate). This represents 17% of the total emissions from the non-domestic building stock, in 2006⁵⁴. Importantly, this estimate only includes energy efficiency measures, and does not include abatement from Combined Heat and Power (CHP), or renewable energy. Inclusion of these technologies will increase the technical potential, although much of this additional potential will not be cost-effective without financial support.

This estimate can be compared with the data in the Carbon Trust's Close Out Database. Across the three non-industry sectors that the Carbon Trust has analysed in detail, an average abatement potential equivalent to 12% of the baseline carbon emissions has been identified⁵⁵. This was based upon data from 2,143 separate organisations. Collectively, the three sectors examined represent 72% of UK public and commercial sector emissions. Therefore, while the analysis is not comprehensive it does provide a high level of coverage. Of these measures, over 90% of the savings are identified as cost-effective, based upon a 10% discount rate. In absolute terms, the Carbon Trust analysis estimated a total carbon savings in the order of 1.9 Mt CO₂/year across the three sectors, which is equivalent to 7 Mt CO₂ at a UK level, after scaling⁵⁶.

It is also useful to compare the results from a cost perspective. This is less straightforward, not least because there are a larger number of methodological assumptions (e.g. energy prices, discount rates, hidden and missing costs) that influence the assessment of the overall cost of abatement. The N-DEEM analysis suggests that the cost-effective potential outlined above can be delivered at an annual economic benefit of £2.3 billion. The equivalent value from the three sectors considered by the Carbon Trust is £925 million.

While caution must be taken in making direct comparison of the results from the bottom-up site surveys with the results from the N-DEEM analysis (see discussion above), this high level analysis suggests that the N-DEEM estimates of the abatement potential are larger than those identified from individual site audits. This is examined further below.

Tier 2: Estimated savings that can be achieved by different sectors, or segment of the non-domestic building stock

The N-DEEM MACC tool does not disaggregate the abatement potential by sector. However, some preliminary sectoral estimates can be made by disaggregating the total abatement potential according to the total energy demand within different sectors, by energy end use. This assumes that the cost-effective potential for lighting is the same in e.g. the retail sector, as for e.g. hotels, for a given level of lighting energy demand. Clearly this is a major simplification, as certain technologies will be more applicable to certain sectors, and the results of such analysis should be viewed accordingly. Insight into the variability of the abatement potential across the non-domestic building stock is provided by the Tarbase project, a £1.4 million low-carbon building project funded by the Carbon Trust and the Engineering and Physical Sciences Research Council. The results make clear that, even within each sub-sector, non domestic buildings are non-homogeneous. Different solutions apply to different sectors (Jenkins et al, 2009). The retail sector was noted as a particular example of where this is an issue. Overall the research suggests that the large variability of the stock means it is not sufficient to assess energy use or abatement potential at a sectoral level, more refined characteristics on building type, occupancy and usage need to be taken into account.

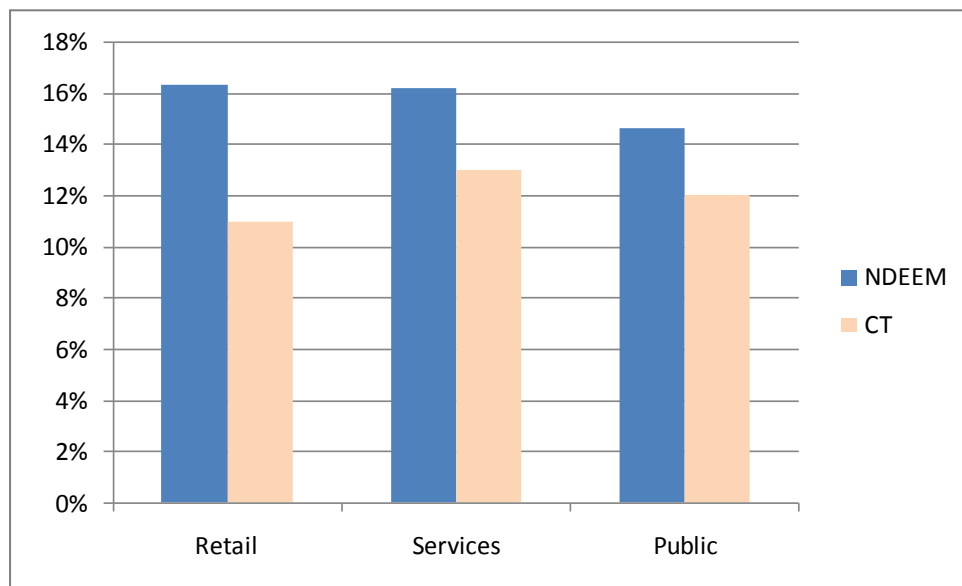
The results from the N-DEEM analysis can be compared with the site survey data within the Carbon Trust's Close Out database. The Carbon Trust has carried out a 'deep dive' into the available data for four sectors: public, services, retail and chemicals sector. The results for the first three of these sub-sectors are shown in the Figure below, and compared with the results from the N-DEEM analysis. To make the comparison it was necessary to re-classify the sectors within N-DEEM, This may add some further uncertainty to the comparison.

⁵³ The 'technical potential' represents all remaining potential for this measure at a given point in time, accounting for the business-as-usual uptake. However, this potential is time-independent in the sense that this does not provide an indication of what might be achievable by this point in time; it is simply all potential remaining, which could actually take another 20 years to fully implement. It will therefore represent an overestimate of the 'realistic' potential.

⁵⁴ To put this in context the latest updates to the building regulations are aiming for a 25% reduction in CO₂ emissions from the previous requirements

⁵⁵ This therefore represents the cumulative savings identified from the site audits. This differs from the implemented savings i.e. those identified measures that were subsequently implemented.

⁵⁶ Scaling was carried out by the Carbon Trust on the basis of the relative contribution of the sites in the Close Out database to the UK population. This assumes that energy use scaled directly with staff numbers.

Figure A 3: Comparison of results from NDEEM and Carbon Trust site surveys at a sectoral level

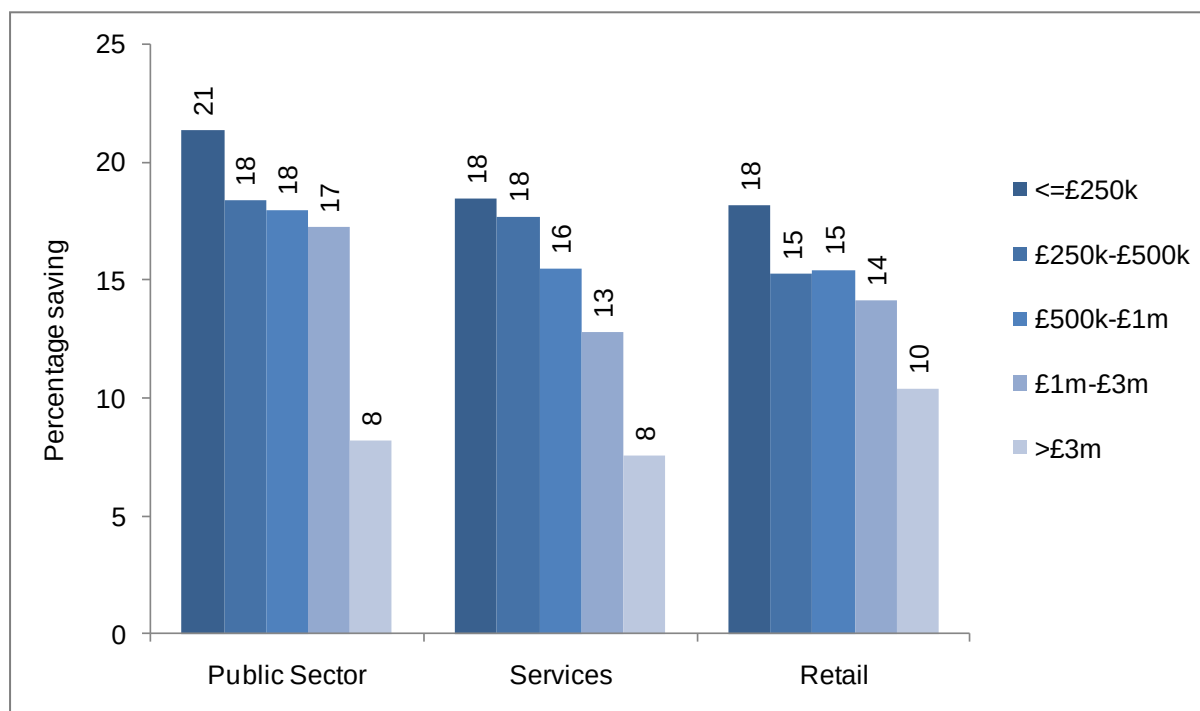
At a **sub-sectoral** level the N-DEEM analysis appears to show a similar variation in abatement potential. In all cases the results from the N-DEEM analysis demonstrate a greater savings potential, when expressed in terms of the % savings, than the results from the site-surveys. Allowing for this overall trend, the results for the services sector and the public sector appear reasonably consistent. However, for the retail sector, the divergence appears to be greater. It is not clear why this might be. It may reflect the fact that certain technologies types are more applicable to the retail sector e.g. refrigeration and lighting. However, it is equally likely to reflect the simplified approach that has been taken to disaggregate the savings in NDEEM⁵⁷. On this basis the results from the sub-sectoral comparison should be treated with caution, not least because the N-DEEM MACC tool was not intended to be disaggregated at this level.

The Carbon Trust have also carried out some analysis on the abatement potential by **size of organisation**. This was designed to examine if the abatement potential was uniform across different sizes of organisation. The percentage savings in each size band have been estimated by the Carbon Trust on the basis of data it has collected through its site audits. In general, the data on the savings from individual measures are considered more accurate than the estimated energy bill at the each of the sites.

The results from the analysis are interesting. For each of the three sectors analysed there is greater savings potential, when expressed as percentage CO₂ savings, in small organisations (defined in terms of energy bill) than in larger organisations. In each sub sector, lower percentage savings were identified in the sample of 'large' organisations, than for organisations in the medium energy bill size bands. Organisations in the 'small' size band had further abatement potential still. For the public sector and retail sector, the percentage savings for the very smallest size band (<£250k) are notable larger, and the percentage savings for the very smallest size band (>3m) notably smaller. For the intermediate size bands the differentiation is less pronounced. A similar pattern can be seen for the services sector, although the savings from the <250k category stand out less. The results are repeated below.

⁵⁷ It may also reflect the large variability in the retail sector, as highlighted in the Tarbase project described above.

Figure A 4: Estimated savings from different sizes of organisation



Source: Carbon Trust (recommendations identified in 2006/07)

Notes: Carbon Trust accounts defined by energy spend. Percentage savings represent the mean value across all sites where data were available.

It is not clear why the results show this variation. One proposal relates to the site audit process. Typically, the site audits will focus on the top-ten most important measures at the site. It is conceivable that the larger sites may have a larger and more complex range of energy uses, so by focusing on the top ten measures the site audits may provide a lower relative coverage of the abatement potential than for the smaller sites. Alternatively, it could be argued that because energy use represents a much larger absolute cost at the larger sites it is subject to a higher level of scrutiny, so many of the 'low hanging fruit' have already been taken up prior to the site audits. Likewise, the larger sites may have more resources to identify and address abatement opportunities.

These results are particularly informative for the current analysis of the unconstrained sector, since the bulk of organisations are likely to fall within the two smallest size bands used in the Carbon Trust analysis⁵⁸. This suggests that a simple assumption that the abatement potential in the unconstrained sector can be allocated pro-rata, based on the proportion of energy use within the sector, may not adequately reflect differences in the abatement potential within different sizes of organisation. This also suggests that the previous estimates of the unconstrained sector may have underestimated the overall abatement potential from the sector (and overestimated the abatement potential from the constrained sector), at least in terms of the % carbon savings. This is highlighted when the results are compared with the weighted average savings for the sub-sector above.

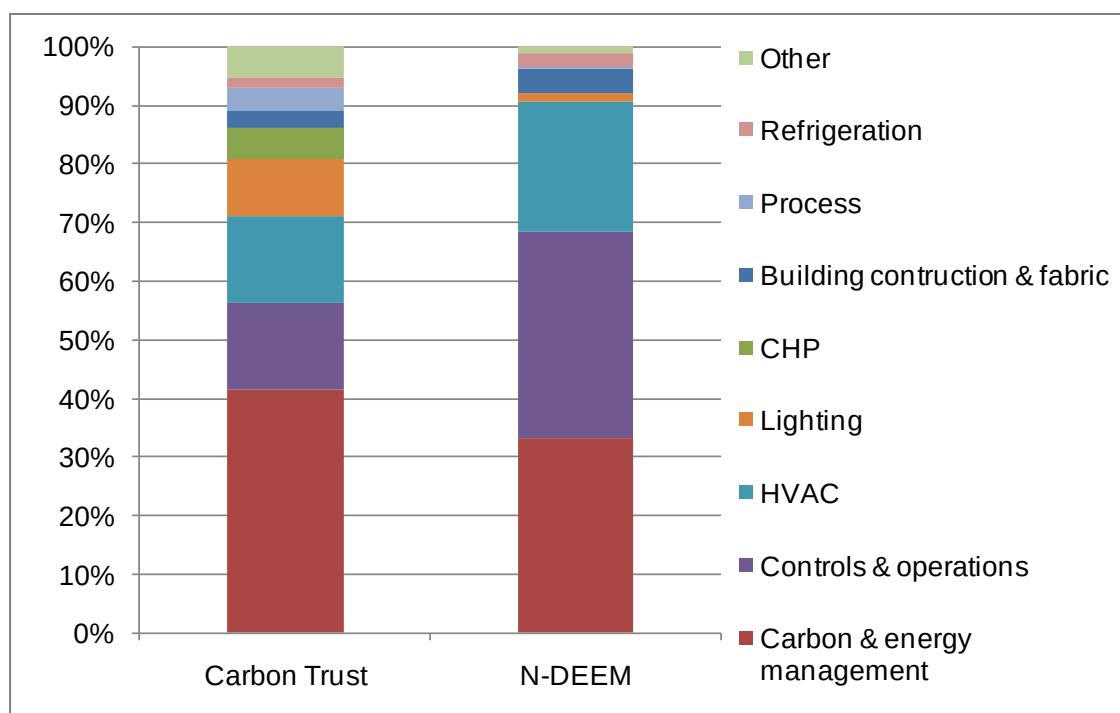
Tier 3: Estimated savings that can be delivered by groups of measures within the existing non-domestic building stock

The third tier of the analysis is concerned with the savings at an individual measures level.

The results from the N-DEEM analysis have been compared with the measures data held in the Carbon Trust's Close Out database. To enable this comparison some reclassification of the measure categories in NDEEM was required. This required a judgement to be made about where to allocate certain measures which will reduce the accuracy of the comparison⁵⁹.

⁵⁸ An electricity bill of £500,000 provides a reasonable approximation of the 6,000 MWh threshold for CRC.

⁵⁹ However, since a similar judgement is required by the site auditors when compiling the data in the Carbon Trust's Close Out database this simplification is not considered to materially affect the outcome.

Figure A 5: Percentage savings associated with each of the measures categories

Notes: Carbon Trust results are based on data for the public, services and retail sector, so are not directly comparable to the coverage within N-DEEM.

Overall, the saving estimates are reasonable consistent in terms of the relative contribution of each of the measures categories. In both cases the savings from carbon and energy management, controls and operations and HVAC dominate the overall cost-effective potential. Lighting is more important in the Carbon Trust mix than in the N-DEEM mix, although N-DEEM assumes significant savings from lighting controls – which have been allocated to controls and operations. One omission from the N-DEEM list of measures is CHP - which was assessed separately in the AEA (2008) report for the CCC.

A further comparison can be made with results from the Carbon Trust's Smart Metering Field Trial. Of the savings identified as part of the trial energy and carbon management measures represented just under 50% of the total savings, with HVAC responsible for 19%. Lighting and controls & operations were the next most important categories. While the results are less comparable than those from the detailed site audits, since they are based on savings associated with smart meters⁶⁰, they do support the importance of the different measures categories shown above.

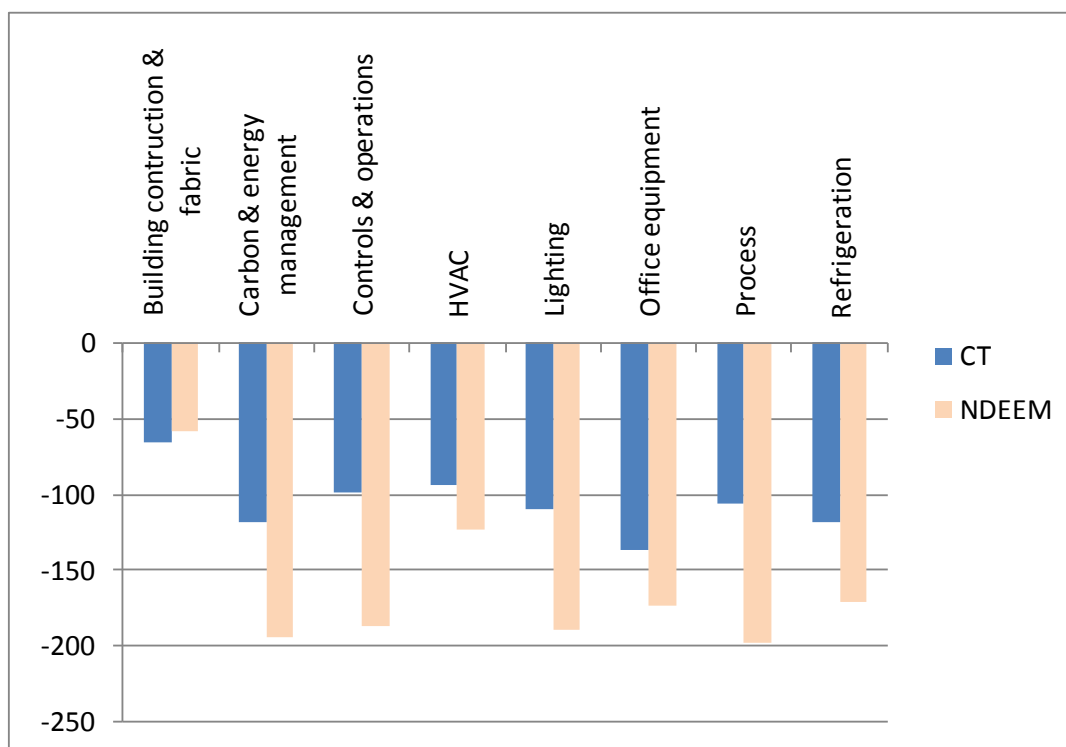
A comparison can also be made with the cost-effectiveness data. In the figure below, the weighted cost-effectiveness of the measures categories in NDEEM are compared with those from the Carbon Trust site audits. In almost all cases the cost-effectiveness in NDEEM is larger than in the Carbon Trust⁶¹. This may suggest that NDEEM underestimates the true cost of the measures, or over estimates the savings. However, it may also reflect a systematic variation in the methodology. For example, the energy prices assumed in the NDEEM analysis were higher than those used in the Carbon Trust analysis, resulting in a larger energy bill saving. However, this difference is not sufficient to explain the full variation. A further consideration is that the lifetime assumptions (over which the capital costs are annualised) in the Carbon Trust analysis are shorter than those used in the NDEEM analysis. This would act to increase the apparent capital cost in the annualised cost-effectiveness calculations. Finally, differences in the mix of technologies assumed in each of the measures categories will also influence to overall weighted cost of the measures.

Therefore, the discrepancy in the cost-effectiveness calculations can in part be explained by methodological differences between the two methods. However, it is not clear if this is sufficient to fully explain the difference or if the NDEEM analysis is more optimistic in its assessment of the cost-effectiveness of the measures.

⁶⁰ The savings also represent a range of deliver mechanisms from site audit to the provision of data remotely. This is likely to be one of the main reasons why a large range was identified for the potential savings from sites participating in the field trial.

⁶¹ The only exception is building fabric, and since these measures are less numerous and typically have a high capital cost the results can easily be skewed by a few large projects.

Figure A 6: Comparison of cost-effective of measures in NDEEM and in Carbon Trust Close Out Database (£/tonne CO₂)



Notes: Results are not directly comparable due to differences in energy price assumptions and technology lifetimes

Technology level comparison

It is also possible to compare the results from the individual technologies that make up the different measures categories.

One important source of information is the Government's Market Transformation Programme (MTP) which includes a range of data on the energy use of products, including detailed stock models and projections of future policy impacts. While MTP and N-DEEM cover in theory the same product groups, direct comparison is not straightforward. MTP holds data on individual products, which are split into different sizes and performance of the respective technologies. These data are then combined to provide information on the overall stock. Changes in the energy performance of the stock, in response to product policies, are then modelled into the future⁶².

In contrast, N-DEEM uses default values on the energy performance of individual technologies which have been selected as being representative of their respective product groups. The stock of these technologies was informed by the original energy audits that underpin the N-DEEM analysis, some of which is also used in the MTP analysis.

While the MTP analysis and the N-DEEM assumptions cannot easily be compared on a like for like basis, they both essentially aim to do the same thing – represent the potential energy use and abatement potential from a range of product groups. On this basis we consider that a high level comparison of the potential savings from each individual product group provides a reasonable basis for validating the results in N-DEEM. To make the comparison, it has been necessary to convert the energy savings into CO₂ saved, different emissions factors are used in NDEEM and MTP⁶³ these have been adjusted to assist with the comparison.

Comparisons are also made, where appropriate, with the findings from the Carbon Trust's Low Carbon Buildings Accelerator. While the sample size for this dataset is small, the data are high quality.

Energy and carbon management measures

⁶² The MTP modelling presents a range of scenarios. These represent the energy savings that can be achieved from the transition between energy efficient and energy inefficient appliances for the product area.

⁶³ EF for 2020 differ in MTP and NDEEM

While the N-DEEM measures list is dominated by technical engineering measures it does contain certain behavioural, with the most important reducing the room temperature and turning off lights. Other behavioural measures relate to appliances, such as energy management of computer equipment. Taken together, these behavioural measures constitute 33% of the total cost-effective abatement from non-domestic buildings.

Energy and carbon management measures also dominate the cost-effective savings identified as part of the Carbon Trust Close Out database. Overall, these measures constitute over 40% of the total savings identified across the commercial, public and retail sectors. This is in some ways not surprising, as these measures are attractive for both the consultants to recommend and the organisations to implement since they represent 'quick wins' with low or no cost and short paybacks times.

Controls and operations

Heating controls are important measures in N-DEEM, representing 28% of the total cost-effective savings. The savings are delivered from measures such as programmable thermostats, optimising start time, and TRVs fully installed. These findings are supported by the Carbon Trust's LCBA that found that simple control measures (PIR, TRV, timers) can offer significant savings in emissions combined with rapid economic payback and appear to be effective in all sizes and types of buildings.

Lighting controls (timers, detectors) are also important, contributing around 21% of the cost-effective savings in N-DEEM.

These measures are closely related to the energy and carbon management measures defined above. In this case the savings relate to the installation of new controls, whereas the former may relate to the **use** of the controls to better manage energy use. In addition, the effectiveness of the measures will diminish as more efficient heating and lighting is installed.

Heating and cooling

In the N-DEEM analysis the use of energy efficient boilers is a measure expected to provide large savings. Since Part L of the current Building Regulations includes minimum standards for replacement boilers the energy savings are generally well understood.

A comparison has been made between the assumptions within N-DEEM and those used within MTP. The latest MTP data for boilers are from 2008 where the savings are based on the difference between the EWP scenario and the reference baseline scenario. The savings figures from the MTP (2008) are 10% lower than the output from NDEEM. It is not clear if this relates to the number of boilers installed, or the assumed efficiency of the boilers.

In the N-DEEM analysis air conditioning was assumed to represent only a small proportion of the total potential. The measure was defined in terms of more appropriate sizing and design and more efficient components. The latest data from MTP suggest there is significantly more potential than suggested by the N-DEEM analysis. While this does not account for the cost-effective potential, it does suggest this is one area where N-DEEM could be improved.

Lighting

Lighting measures are important measures in the Carbon Trust Close Out Database, but their contribution to the overall cost-effective potential in N-DEEM is lower (2% of overall savings). Evidence from the Carbon Trust's LCBA found that lighting measures can offer significant savings in emissions. Furthermore, lighting measures were also found to be effective in all sizes of buildings. This suggests that in broad terms the overall savings that have been estimated in N-DEEM for lighting measures may underestimate the cost-effective potential.

A comparison has also been made with data from the Market Transformation Programme on Non-domestic lighting. The comparison indicates quite a large variation between the results from N-DEEM and those provided by the MTP for the Best Available Technology (BAT) scenario. While the MTP estimates will include some lighting measures that are not included in N-DEEM i.e. industrial lighting, this initial analysis does suggest that the N-DEEM estimate may underestimate the total technical potential available from lighting measures.

Building fabric

The N-DEEM analysis suggests that building fabric measures, such as insulation, contribute a relative small proportion to the cost-effective potential. The technical potential is much greater, but these measures are not considered to be as cost-effective as certain other measure types.

For Building Fabric measures the Carbon Trust's LCBA suggested that these measures can deliver significant carbon savings (up to 50%) which can be cost-effective where a deep refurbishment is already intended. However, building fabric measures are not always cost-effective for all buildings.

Omitted measures

The review has also highlighted certain measures that are not included in the N-DEEM model. Alternative energy technologies are one important omission – although these were included in the most recent update of the model for the CCC. However, certain other energy efficiency measures have been identified. These include voltage optimisation.

Appendix 4

Detailed methodology for mobile sources

Definition of the sector

For the purposes of this study the ‘unconstrained sector’ is defined in terms of the sites and sources that are not covered by the main carbon abatement regulations: CRC, EU ETS and CCAs. However, these regulations only target direct emissions from stationary combustion and do not include direct emissions from mobile sources (e.g. transport). In the transport sector the primary regulations target suppliers of vehicles, such as limits on g CO₂/km as opposed to through cap and trade schemes placed on end users. On this basis the energy use and emissions from the transport sector cannot be classified as constrained or unconstrained in the same way as energy use within commercial buildings, for example.

Therefore, to ensure that the results of the analysis of emissions from the transport sector are comparable with results elsewhere in the study, it is necessary to estimate the proportion of the UK’s transport related CO₂ emissions that arise from organisations whose stationary emissions fall within the unconstrained sector. In the absence of better data, an assumption has been made that a large proportion of organisations that fall within the unconstrained sector are likely to be Small and Medium sized Enterprises (SMEs) i.e. companies employing fewer than 250 people. In practice, certain SME sites will form part of the constrained sector (for example, if their landlord is part of the CRC), likewise some non-SMEs may have sites that fall outside the constrained sector.

Classification of emissions

As a starting point, it is necessary to identify the proportion of UK transport emissions that are associated with business related travel. This has been defined in accordance with the World Resource Institute (WRI) company carbon reporting as defined by the Greenhouse Gas Protocol. Two categories of business travel are defined:

- **Direct.** This includes any vehicle **owned by the company**, from cars or owner operator vans through to fleets and smaller freight operators typically running rigid rather than heavier articulated Heavy Goods Vehicles (HGVs). This will also cover company cars, taxi firms and hire car firms.
- **Indirect.** This includes travel associated with business activities but **not in company owned vehicles**. Examples of this are travelling by rail to meetings, commuting to work in a personal car, or travelling to meetings using a privately owned car.

This distinction is also important from a policy perspective. Certain businesses within the unconstrained sector will have direct control or influence over the emissions i.e. through their fleet management. However, for other businesses, where the contribution of commuter travel is more important, they only have an indirect influence.

Calculation of CO₂ emissions from the SME sector

A top-down methodology has been developed which draws upon the data in the UK Greenhouse Gas Inventory (GHGI)⁶⁴, and other sources, to disaggregate the proportion of UK transport emissions that are associated with SMEs. The results from this approach have been compared against those from alternative estimates to cross check and refine the findings.

⁶⁴ The GHGI represents the official data on historical emissions of greenhouse gasses within the UK, as reported by the UK Government to the UNFCCC

The methodology is described in the following steps.

Step 1: Assessment of emissions by mode

The GHGI calculates road vehicle CO₂ emissions using vehicle-km data from Transport Statistics Great Britain⁶⁵ (TSGB) and then multiplying these activities with emission factors appropriate to the different types of vehicles. This gives a bottom-up inventory. These data are then normalised to the total fuel purchased in the UK to derive a CO₂ emissions total that is consistent with fuel sales. This approach is used to derive emissions estimates for 2-wheelers, Passenger Cars, Light Commercial Vehicles (LCVs), and Heavy Duty Vehicles (HDVs). The GHGI also provides CO₂ emissions totals for domestic air transport, segmented by take-off/landing emissions and cruising emissions (and as a memo item, international air transport).

For rail travel, the CO₂ emissions data in the GHGI encompass haulage of freight as well as passenger travel. For simplicity, commuter and business rail transport emissions were estimated bottom-up using DfT's National Travel Survey data, and emissions factors from Defra's company reporting guidelines. Since the factors used in the company reporting guidelines are derived from the GHGI then this method is consistent with the approach for the other modes, but avoids the need to disaggregate freight-related emissions from the GHGI data. Since all freight operators are assumed to be larger than SMEs then the omissions of these emissions will not influence the overall results.

The GHGI also includes data on emissions from on-site transport. This includes aircraft vehicles and forklift trucks. It has been assumed that the bulk of these emissions will arise from organisation in the constrained sector, so have not been included in the current analysis. However, emissions from agricultural sources (e.g. farm machinery) have been included. This is because we expect a large proportion of farms to qualify as SMEs.

The unapportioned transport emissions are shown in the figure below.

Table A 10: Unapportioned transport CO₂ figures by mode (from UK 2008 Greenhouse gas inventory)

Category	2008 kt CO ₂
Passenger cars	70,912
HGV	23,474
Light commercial vehicles	15,651
Bus and coach	4,851
Agricultural vehicles	4,648
Civil aviation (domestic)	1,611
Passenger rail travel	1,258
Taxis	1,169
Two-wheelers	620
Grand total	124,196

Step 2: Assessment of business related emissions

In the next step the emissions for each mode of transport were allocated to either business related or non-business related travel.

For road transport this amounts to splitting the total vehicle km into either business, or non-business, related travel. A further distinction was made between fleet emissions and emissions associated with commuter/business travel. However, this is not necessarily straightforward. While it is relatively easy to define a system boundary for reporting fleet and commuter emissions for a specific organisation, it is less so for the UK as a whole. For example, a SME may own or operate a fleet of vehicles, e.g. some taxis. However, the users of the vehicles could be other SMEs, larger business users, or could be non-business users. Therefore, if the emissions are allocated on a 'direct' basis, then the results will differ (for the given mode⁶⁶) from where an 'indirect' approach has been used to allocate the emissions. Hence, for the illustration of taxis, from the SME taxi owners' perspective the CO₂

⁶⁵ TSGB is a major publication within the scope of National Statistics and provides an accurate, comprehensive and meaningful picture of transport patronage in Great Britain

⁶⁶ This is more applicable to certain modes than others. For example, vans and good vehicle are more likely to be utilised by just the owning business (with fleet rental a notable exception), whereas the purpose of coaches, buses and taxis is to provided passenger transport, so these modes will feature in both the fleet (of the owning businesses) and the usage (of the businesses that utilise them) fields.

emissions are direct business emissions, whereas from the users' perspective the emissions are either indirect business (SME or large business) or private usage.

For this reason emissions have been estimated both on a 'direct' and an 'indirect' basis. These estimates cannot be combined at a UK level as this will effectively double count a certain proportion of the emissions. This is described further, in the context of the SME proportion of the emissions, under 'Step 3' below.

Direct emissions

In the next step, the total emissions for each mode of transport were allocated to either business related or non-business related emissions from the perspective of the vehicle owners – this decoupled emissions from privately owned vehicles.

Table A 11 shows the percentages used to identify the direct emissions (and by definition, work related emissions) from those in Table A 10. An explanation of each percentage is provided below.

Table A 11: Direct related percentages (from the perspective of the vehicle owners)

Category	Direct %
HGV	100%
Passenger rail travel	100%
Agricultural vehicles	100%
Bus and coach	100%
Taxis	100%
Civil aviation (domestic)	100%
Light commercial vehicles	96%
Passenger cars	10%
Two-wheelers	0%

As shown above, we have assumed that all emissions from HGVs through to Civil aviation will be associated with vehicles owned by businesses. This is unsurprising, as the vehicles contained in this category are impractical for personal use, or at least emissions from privately owned vehicles is negligible. One exception to this would be taxis, however there are insufficient data to prove otherwise.

Light Commercial Vehicles are used primarily for work purposes; 96% of mileage according to Office for National Statistics data.

Passenger car business use is primarily in cars that are owned and used privately, this explains why direct business emissions from passenger cars is quite low at 10% (derived from National Travel Survey data). We have assumed that all business emissions from passenger cars relates to business owned vehicles.

Two wheelers have been excluded following a recent survey on motor cycle safety which suggests this mode of transport is dominated by private use (TRL, 2009).

Indirect emissions

In this section, indirect business emissions are estimated from the perspective of the traveller. This includes emission associated with passenger travel that takes place in the UK in relation to business activities. This should be considered illustrative.

The analysis **excludes emissions outside of the UK** i.e. it only includes domestic emissions. In practice, certain transport-related emissions from UK SMEs will relate to transport that occurs overseas e.g. international business meetings. For consistency with the analysis of the emissions from stationary sources, and with reporting against the UK carbon budget, these emissions have not been estimated.

The analysis also **excludes emissions associated with product supply chains** e.g. the transportation of paper to an office. In theory, indirect emissions from businesses would also include the transport emissions associated with the transport of products and materials. Including these emissions adds further complexity, and its inclusion would require further steps to ensure the emissions involved were not double counted. Therefore, the current analysis has been restricted to indirect emissions associated with passenger transport i.e. emissions from employees.

Similar to above, Table A 12 sets out the proportions of indirect emissions which have been allocated to the same categories of vehicle determined in step 1.

Table A 12: Indirect work related percentages (from the perspective of the travellers)

Category	Indirect %
Passenger rail travel	47%
Civil aviation (domestic)	45%
Passenger cars	43%
Bus and coach	23%
Taxis	12%
Agricultural vehicles	0%
Two-wheelers	0%
HGV	0%
Light commercial vehicles	0%

According to the National Travel Survey, in 2006, 47% of rail travel was for business use or commuting. Similarly, according to surveys undertaken by the Civil Aviation Authority, 45% of domestic air travel is for work purposes.

Passenger cars, owned privately, are also used for travelling to work meetings or commuting 43% of the time, based on kilometres travelled data from the National Travel Survey.

In terms of bus and coach passengers, 23% are travelling on work purposes or commuting, according to National Travel Survey data, and for taxis this is around 12% by the same source.

Agricultural vehicles, two-wheelers, HGVs and Light Commercial Vehicles⁶⁷ are not formally used for transporting passengers, and therefore have no indirect passenger transport emissions associated with them.

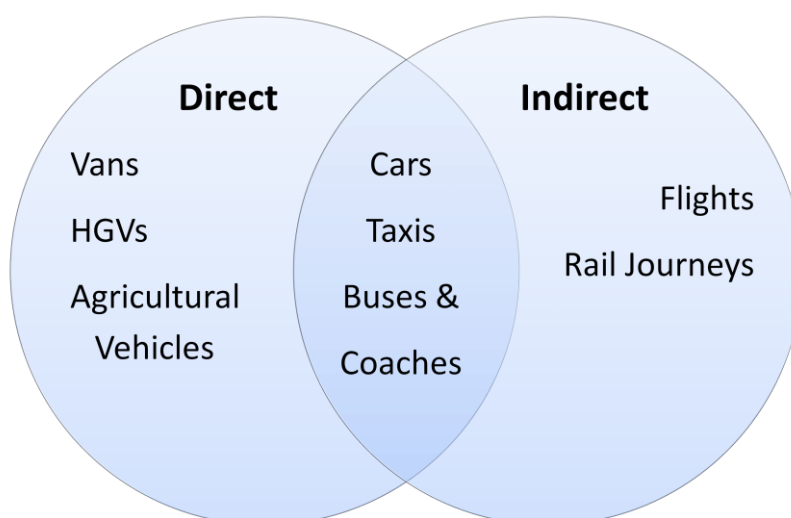
Step 3: Assessment of SME component of business related emissions

In the final step, the business related travel was disaggregated into either the SME group or the non-SME group. This required some assumptions to be made about usage of different modes of transport by SME and non-SME businesses, drawing on published statistics where available.

Definition of emissions

A distinction was made between direct and indirect emissions, from the perspective of the SME sector. This is more complex at this level of disaggregation as it needs to account for the ownership of different vehicles by company size. This is explained in the Venn diagram below, and following commentary.

⁶⁷ This is something of a simplification because light commercial vehicles comprise both vans and minibuses, but the former dominate

Figure A 7: Venn diagram of direct and indirect interactions from SME-related transport

The direct section shows vehicles of which a proportion are likely to be SME owned. This means the emissions from the vehicles are the direct responsibility of the owner-operator or SME. For certain vehicles within this group (e.g. HGVs) indirect emissions (from passenger transport⁶⁸) are assumed to be zero.

The indirect section includes activities whereby the vehicles are not necessarily owned by SMEs, but emissions can be attributed to SMEs from journeys undertaken by SME employees. For certain modes none of the transport service providers are expected to be SMEs. Hence, direct emissions from SME are assumed to be zero. This circumstance is only assumed to be applicable to aircraft and trains.

The area of overlap between the indirect and direct sections is where SMEs can be attributed emission on both a direct and indirect basis. This relates to vehicles, such as buses and taxis that can be owned by SMEs but also used by other SMEs for business travel.

Two wheeler emissions are dominated by private use, and given their very small overall contribution, the SME proportion has been approximated to zero for both direct and indirect emissions.

The percentages used to allocate direct emissions to SMEs are shown in Table A 13 below:

Table A 13: Direct SME emissions

Category	Direct SME %
Taxis	100%
Agricultural vehicles	95%
HGV	72%
Passenger cars	59%
Bus and coach	55%
Light commercial vehicles	50%
Passenger rail travel	0%
Two-wheelers	0%
Civil aviation (domestic)	0%

⁶⁸ In practice, HGVs may constitute indirect emissions to SMEs through supply chain emissions e.g. by delivering products used by SMEs. As described above the current analysis of indirect emissions is restricted to passenger transport, so these emissions are excluded.

All taxi operators are assumed to be SMEs, and the majority of agricultural emissions have been allocated to SMEs.

A Market Research Report by Market and Business Development Ltd provided information on the number of freight operating companies by employment. Using employees as a proxy for the proportion of vehicles a company owns in its fleet, 72% of all HGV emissions are SME related. It is reasonable to assume that there are however differences in the fleet compositions of SMEs and larger companies. For example smaller, rigid vehicles are likely to be more typical of SMEs, with higher polluting large articulated vehicles characterising large firms. Interestingly, emissions per kilometre from these vehicles, assessed using GHGI data, are in fact very similar leading to no need to make a distinction here. The reason emissions from small vehicles and large vehicles are more similar than physics would suggest is because of their differing drive cycles. Smaller vehicles operate a far more interrupted, congested drive cycle, where as the articulated vehicles tend to roll relatively efficiently along motorways.

The proportion of company owned passenger cars which are SME related has been estimated using the number of people employed by SMEs from BIS employment statistics. This assumes that company cars are evenly distributed among small and large employees, for which there is limited credible data to prove otherwise.

Consultation with trade associations in the Bus and Coach industry has been used to estimate a weighted average of bus and coach operators whom are SMEs – this is 55%.

The number of Light Duty Vehicle users which are SMEs, excluding large fleets such as BT and Royal Mail, has been estimated at 50%. In the absence of empirical data, this was based on AEA's understanding of the organisations that own large fleets and have utilised the Van Best Practice programme.

Trains and aircraft have assumed to be owned only by companies with more than 250 people. This is the reason for their exclusion from the direct area of the SME Venn diagram above.

The percentages used to allocate indirect emissions to SMEs are shown in Table A 14 below:

Table A 14: Indirect SME emissions

Category	Indirect SME %
Taxis	59%
Passenger rail travel	59%
Passenger cars	59%
Bus and coach	59%
Civil aviation (domestic)	20%
Agricultural vehicles	0%
Two-wheelers	0%
HGV	0%
Light commercial vehicles	0%

Business travel and commuting using taxi, rail, car and bus or coach is assumed to be proportionate to the employees in the sector. The SME allocation has therefore been made on the basis of the proportion of employees who work for SMEs, based on BIS statistics.

Air travel has been allocated on a slightly different basis, with the SME proportion scaled back. An estimate of 20% has been applied, which assumes domestic air travel is more popular in larger companies which tend to have more satellite offices.

For agricultural vehicles through to light commercial vehicles it is assumed that none of these vehicles are used for passenger transport.

Further explanation of emissions which overlap both direct and indirect categories

The bullet points below explain why and how cars, taxis and buses and coaches contribute to both the direct and indirect totals, and appear in the overlap area of the Venn diagram. It is for these modes in particular where the risk of double counting emissions is greatest.

- **Cars** - company cars and hire cars owned by SMEs generate some direct emissions. At the same time however, an SME employee commuting to work or travelling to a meeting in a private car is an indirect emission of the SME.
- **Taxis** - we have assumed all taxi operators to be SMEs, based on very few taxi firms having over 250 employees. It follows, that all taxi emissions are direct from the perspective of vehicle ownership. In addition, some of these emissions can be allocated as indirect emissions to SMEs when SME employees commute or travel to meetings by taxi.
- **Buses and coaches** - about 55% of bus and coach operators have fewer than 250 employees, and therefore all their emissions are direct from the perspective of the vehicle owners. Similar to the case with taxis however, there are additional, indirect emissions whereby services are used by SME employees to commute or travel to meetings.

It follows that we have derived direct and indirect emissions totals for the SME sector that are non-additive.

Results

Table A 15 below shows the direct emissions outlined in step 1, broken down by direct percentages provided in step 2 for business related emissions and step 3 for SME-related emissions.

Table A 15: Direct emissions from the SME sector

Category	Direct SME kt CO ₂
HGV	16,860
Light commercial vehicles	7,510
Agricultural vehicles	4,416
Passenger cars	4,305
Bus and coach	2,684
Taxis	1,169
Two-wheelers	-
Civil aviation (domestic)	-
Passenger rail travel	-
Grand total	36,943

HGVs contribute the largest amount to direct emissions. This is influenced by their high overall emissions, and the fact that all vehicles are assumed to be business owned – rather than HGVs being disproportionately popular for SMEs. The contribution from Light Commercial Vehicles, agricultural vehicles, taxis, buses and coaches is however influenced by a high level of SME ownership. The contribution of SMEs to total passenger car emissions is less significant, although this remains an important source of direct emissions from SMEs.

Direct emissions from aviation and rail emissions are assumed to be zero on the basis that the owners and operators of these modes are unlikely to be SMEs. Similarly, two-wheelers are dominated by private use rather than business use.

Table A 16 below shows the indirect emissions resulting from the SME sector.

Table A 16: Indirect emissions from the SME sector

Category	Indirect SME kt CO ₂
Passenger cars	18,294
Bus and coach	666
Passenger rail travel	349
Civil aviation (domestic)	146
Taxis	85
Agricultural vehicles	-
Two-wheelers	-
HGV	-
Light commercial vehicles	-
Grand total	19,540

Overall, indirect emissions are just over half the total for direct emissions (53%). Passenger cars dominate, through both commuting and business use. These emissions are over 4 times larger than the estimated emissions from company owned vehicles.

Bus and coach and taxi emissions are much lower, in part reflecting the relatively small amount of journeys associated with business purposes. Aviation and Rail emissions are also small, reflecting the smaller overall contribution of these modes to total UK transport emissions.

Step 4: Assessment of emissions by industry and by size of organisation

The final step of the emissions estimate analysis takes the emissions totals presented above for direct emissions, and allocates them to different industry sectors. This step of the analysis is subject to greater level uncertainty, as it treats all businesses equally and does correct for any SME-specific characteristics.

Disaggregation by sector

The Blue Book publishes the National Accounts for the UK Economy, based on data from the Office of National Statistics. These data include estimates of the CO₂ emissions associated with the 12 economic sectors in the National Accounts classification scheme, and also a total for road transport CO₂ for the UK. The emissions estimate is based on the data in the UK GHGI that have been reclassified to the economic sectors used in the National Accounts.

AEA is currently carrying out a project for the Office of National Statistics to disaggregate the road transport emissions by economic sectors. This method uses Purchase Inquiry data, which provide information on purchases (in monetary terms) of fuel (petrol and diesel), by 5-digit industry code. Although the results from this analysis are not yet published, some of the preliminary analysis showing the splits of fuel purchase by industry sector has been used in this project. This information is shown in Table A 17 below (for consistency with the above method, two wheelers have been excluded).

Table A 17: Total road transport CO₂ by industry sector

Row labels	Road transport CO ₂ by sector
Transport, storage and communication	33,018
Wholesale and retail trade; repairs	20,558
Real estate, renting and business activities	13,763
Manufacturing	11,330
Other community, social and personal service activities	8,438
Construction	8,055
Financial intermediation	6,069
Mining and quarrying; electricity, gas and water supply	1,696
Hotels and restaurants	1,564
Health and social work	1,487
Agriculture, hunting and forestry; fishing	987
Education	571
Grand total	107,537

Transport, Storage and Communication dominate road transport emissions at just under a third of road transport emissions from all industries.

Disaggregation of SME-only emissions by industry

The results presented above were then split between SMEs and larger organisations using the percentage of turnover from sector that is associated with organisations with under 250 employees. This method is consistent with the World Resources Institute⁶⁹ (WRI) recommendation for company carbon reporting, which states that market value of goods is the most appropriate approximation for allocating regional/national subsidiary or corporate CO₂ emissions.

Table A 18 below shows the percentage of the total turnover in each of the industries for which SMEs are responsible.

Table A 18: Percentage of turnover that is related to SMEs, by industry sector

Industry sector	% of turnover
Agriculture, hunting and forestry; fishing	86%
Health and social work	84%
Construction	71%
Real estate, renting and business activities	69%
Education	68%
Hotels and restaurants	57%
Wholesale and retail trade; repairs	49%
Other community, social and personal service activities	43%
Transport, storage and communication	39%
Manufacturing	36%
Mining and quarrying; electricity, gas and water supply	13%
Financial intermediation	0%

These percentages were then weighted using the emissions data for each industry sector reported in Table A 19. This gives the relative contribution from each of the industry sectors to the overall SME related emissions. These percentages can then be used to disaggregate the direct emissions from SMEs to each industry sector.

⁶⁹ WRI are responsible for the Greenhouse Gas Protocol, an internationally recognised standard for accounting carbon emissions.

Table A 19: SME transport emissions percentages by industry sectors

Industry sectors	SME transport emissions
Transport, storage and communication	26%
Wholesale and retail trade; repairs	20%
Real estate, renting and business activities	19%
Construction	12%
Manufacturing	8%
Other community, social and personal service activities	7%
Health and social work	3%
Hotels and restaurants	2%
Agriculture, hunting and forestry; fishing	2%
Education	1%
Mining and quarrying; electricity, gas and water supply	0%
Financial intermediation	0%
Grand total	100%

In practice, the total emissions allocated to SMEs are around 3,000 kt, or 6%, larger using this approach than the total for road transport calculated using the GHGI method. We consider that the ONS estimate of SME road transport CO₂ is likely to be an overestimate because no account is taken for the different driving patterns and distances of SME trucks and vans and larger organisations' fleets. (As a generalisation, the trucks and vans of larger organisations travel larger distances than those of SMEs). The GHGI method uses surveys, which do account for this. It follows that as a check of the GHGI estimate, this aligns well with expectations giving confidence in the GHGI method.

Table A 20 below applies these percentages to the direct transport emission total calculates using in the GHGI method described through steps 1 to 3.

Table A 20: Direct transport emissions from SMEs by industry sector

Industry sector	Direct SME CO ₂
Transport, storage and communication	9,595
Wholesale and retail trade; repairs	7,571
Real estate, renting and business activities	7,074
Construction	4,266
Manufacturing	3,030
Other community, social and personal service activities	2,717
Health and social work	932
Hotels and restaurants	664
Agriculture, hunting and forestry; fishing	634
Education	292
Mining and quarrying; electricity, gas and water supply	169
Financial intermediation	-
Grand total	36,943

The highest potential emissions are estimated to arise from HGV emissions in the Transport, Storage and Communication industry.

Appendix 5

Supplementary material for the transport abatement analysis

Description of behavioural measures

Haulage fleets

This measure is based on work for CfIT by McKinnon and aims at efficiency improvements in the following areas:

- Number of specific journeys made by individual products (the handling factor).
- Mean length of each link in the supply chain (average length of haul).
- Modal split.
- Average load carried when laden.
- Proportion of distance running empty.
- Fuel efficiency with which vehicles are operated (such as driving style).
- Fuel source.

It would be reasonable to expect that if gains don't require capital investment and generate financial savings which go straight to a company's bottom line, the sector would self regulate. However, many SME trucks are owned and operated by one person whose business does not have the scope for collaborative distribution and its financial benefits – deliveries are too variable and bespoke. Even in the largest supply chains, secretive behaviour over distribution patterns for fear of losing competitiveness can prevent collaborative distribution and considerable fuel/carbon savings.

It follows that the large carbon abatement potential from this collection of measures could prove difficult to unlock – especially for SMEs.

SAFED (Safe And Fuel Efficient Driver) for buses

SAFED is a Government support programme to encourage eco-driving. In this case it targets bus drivers as HGVs, vans and aggregates have already had part funded training schemes provided. Smarter choices.

Smarter choices

Smarter choices encompasses a range of measures, for example:

- Destination-based measures to reduce car use, e.g. workplace or school travel plans.
- Changing access to cars, e.g. car clubs and car-sharing schemes.
- Action to increase individual awareness of alternatives to the car, e.g. public transport information and marketing, travel awareness campaigns and personalised marketing.
- Measures to reduce the need to travel, e.g. teleworking (video-conferencing) or home shopping.

Figures quoted are taken from Defra's study of local authorities who have introduced Smarter choices packages.

Eco-driving

This includes a number of practices to improve fuel consumption per unit of distance, for example:

- Accelerating gently, keeping speed constant and changing gear at the optimal time (between 2,000 and 2,555 rpm).
- Adhering to speed limits.
- Limiting the use of air conditioning (estimated to add 10–14% to fuel consumption).
- Reducing drag by driving with the windows closed and empty roof racks removed.

- Avoiding idling the engine.
- Not warming the engine up before starting off.
- Ensuring the tyres are filled to the optimum pressure.
- Shedding excess weight from the car.
- Keeping a safe distance from the car in front, as sharp braking wastes fuel.

Savings are based on a number of studies from across Europe, including the Safe and Fuel Efficient Driver (SAFED) scheme by the DfT (described above).

Intelligent Transport Systems (ITS)

Intelligent Transport Systems (ITS) is the generic term used to describe all aspects of using information technology and telecommunications for transport applications. ITS tools use modern computing and communications technologies to collect information about the current state of the transport network, process it and either directly manage the network (e.g. traffic signals), or allow people to decide how best to use the network (e.g. incident detection, travel news) (DfT 2009). Although current focus on ITS is reducing congestion, as a corollary there should be clear CO₂ benefits. However, it should also be noted that the rebound effect of increased travel due to better traffic conditions may increase CO₂ on the whole.

Unfortunately it is very difficult to quantify the direct affects of ITS measures on CO₂ emissions. This is mainly due to the fact that ITS measures are not usually introduced one at a time, but as a package, and the nature of that package will vary in each specific case.

Similarly to other measures, the proportion of savings which SMEs could make could be identified by comparing their contribution to overall emissions to the overall savings.